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MSFC CRACK GROWTH ANALYSIS COMPUTER PROGRAM, VERSION II (USERS MANUAL)

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16. ABSTRACT

An updated version of the George C. Marshall Space Flight Center Crack Growth Analysis Program is described. The updated computer program has significantly expanded capabilities over the original one. This increased capability includes an extensive expansion of the library of stress intensity factors, plotting capability, increased design iteration capability, and the capability of performing proof test logic analysis.

The technical approaches used within the computer program are presented and the input and output formats and options are described. Details of the stress intensity equations, example data, and example problems are presented in the Appendix.

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TABLE OF CONTENTS

	Page
SUMMARY	1
INTRODUCTION	2
TECHNICAL APPROACH	11
SUBROUTINES	12
PROOF (For Proof Test Logic)	12
PTCGR, TRANS, TCGROW (For Growth)	13
KANAL (For Stress Intensity Analysis	13
DAMAGE (For Crack Growth Rate Determination)	14
RETARD (For Effects of Retardation)	24
INTP (For Interpolation of Rate and Stress Intensity Tables)	25
MAIN (For Input, Output, Design Iterations and Control)	26
INPUT	27
CONTROL OF OUTPUT	40
INPUT FOR ADDITIONAL USE	42
ITERATION ON THICKNESS AND INITIAL CRACK SIZE	43
PROOF TEST LOGIC	44
REFERENCES	45
CRACK GROWTH RATE DATA	A-1
CRACK GROWTH ANALYSIS EXAMPLE	B-1
STRESS INTENSITY FACTORS EQUATIONS	C-1
COMPUTER PROGRAM LISTINGS	D-1

FOREWORD

The computer program described in this manual was developed under Contract Numbers NAS8-31101 and NAS8-31624. These Contracts were monitored by C. Bianca of the George C. Marshall Space Flight Center. K. Roper performed all the computer program coding. The author would like to acknowledge the informative technical discussions held with J. E. Collipriest, Jr., R. M. Ehret, and A. F. Liu during the course of this work.

INTRODUCTION

In order to include the important consideration of structural failure due to the presence of flaws and crack-like defects in aerospace hardware; it is necessary to have a computer program capable of performing crack growth analysis that is easy to use and generally applicable. The need for a computer program (as opposed to simple hand calculations) arises from the complexity of growth descriptions required for crack growth analysis of real materials in complex structure under a variety of loading and environmental conditions. The MSFC crack growth computer program developed by Del West was designed to meet this need.

The MSFC crack growth computer program calculates crack growth for part through cracks, through the thickness cracks and cracks which are transitioning from part through cracks to through the thickness cracks. The computer program has been written to be flexible in its operation and to be easily adapted and changed as fracture mechanics technology changes and/or the design usage of the program changes.

The computer program is essentially an integration routine which calculates crack growth from an initial defect size and terminates calculation when the crack is sufficiently large for a critical condition (instability or rapid growth) to be reached. The initial defect size may be designated by the user or established

by the computer program on the basis of proof test logic. In addition, if a design life is not met for a particular structure, the program has the capability of varying the thickness of the structure or initial defect size so as to establish the geometry which will meet the design requirements.

During the period when a crack is a part through crack, crack growth in the depth and surface directions may be different due to variations in stress intensity factors and/or directional dependence of material properties. The MSFC computer program considers both of these effects and hence incorporates realistic crack shape changes. During the period when a crack is transitioning from a part through crack to a through the thickness crack, the crack lengths on the backside and the frontside are different. The MSFC computer program tracks the growth of these two dimensions separately; evaluating the stress intensity factors at each surface until these dimensions are the same and the crack has completed its transition to a through the thickness crack.

The computer program allows two different methods of load input. For each step in the loading block, the user specifies either: (1) Maximum Stress, Minimum Stress, Number of Cycles or (2) Maximum Stress, Stress Ratio, Number of Cycles. It should be noted that if crack growth mechanisms other than fatigue are

being considered (e.g., static stress corrosion) the appropriate rate variable can be used instead of cycles (e.g., time at load) in conjunction with appropriate material constants as described below to perform a wide range of phenomenological studies.

The use of a limit load (a load which may be higher than any load in the actual spectrum) to determine the end of design life is a common practice. The MSFC computer program has therefore been written to consider a separate limit load (apart from those in the spectrum) and to determine when it causes failure. However, after failure due to limit load occurs, the crack growth calculation continues. The limit load failure information is included in the output.

The crack growth rate material properties may presently be input into the program in any of four formats: (1) Paris equation with upper and lower cutoffs in stress intensity factor; (2) Forman equation with upper and lower cutoffs in stress intensity factor; (3) Collipriest-Ehret equation with additional upper and lower cutoffs in stress intensity factor; (4) tabulated as a function of stress intensity range and stress ratio. An important feature of the material property description is that different material properties (crack growth equations, fracture properties, yield stress, etc.) may be designated for each step in the loading spectrum. Thus varying temperatures and environments may be considered.

The MSFC crack growth computer program has the capability of utilizing any one of three crack growth retardation models. Of course, the effects of retardation on crack growth will not be considered if the user does not request it. The three models presently available are: (1) Willenborg; (2) Wheeler; (3) Grumman Closure Model.

The module which performs stress intensity calculations currently includes stress intensity equations for the following geometries:

1) Crack in a finite width finite thickness plate - part through crack, transition crack, through crack.
2) ASTM E399 compact specimen - through crack.
3) Single crack emanating from a hole - corner crack, internal crack, transition crack, through crack.
4) Two cracks emanating from a hole - corner crack, internal crack, transition crack, through crack.
5) Single crack emanating from a pin loaded lug - corner crack, internal crack, transition crack, through crack.
6) Two cracks emanating from a pin loaded lug - corner crack, internal crack, transition crack, through crack.
7) Crack emanating from a notch - corner crack, internal crack, transition crack, through crack.
8) Cracks emanating from double notches - corner crack, internal crack, transition crack, through crack.

9) Cracks emanating from shoulder radii - corner crack, internal crack, transition crack, through crack.

As many runs (each with varying input conditions) as desired may be stacked. As additional runs are made, only that section of data which is changed (i.e., loads, material properties, or geometry) need be reentered. Output format can include tabulated and/or plotted data. Minimum tabulated output for each run consists of information on input data and failure (crack lengths, cycles, etc.) as well as crack lengths, stress intensity factors, and crack growth rates for the first and last cycle of each stress level in the first load block applied as a part through crack, transitional crack or through crack. Additional information (crack lengths, stress intensity factors, and crack growth rates) for particular blocks and loading steps may be requested by the user. The plotted output consists of plots of surface and crack depth lengths plotted against the number of loading blocks and cycles. The user may specify plotting increments or simply use increments chosen by the computer program.

A flow chart showing all subroutines is presented in Figure 1, and a description of each subroutines primary function is presented in Table I.

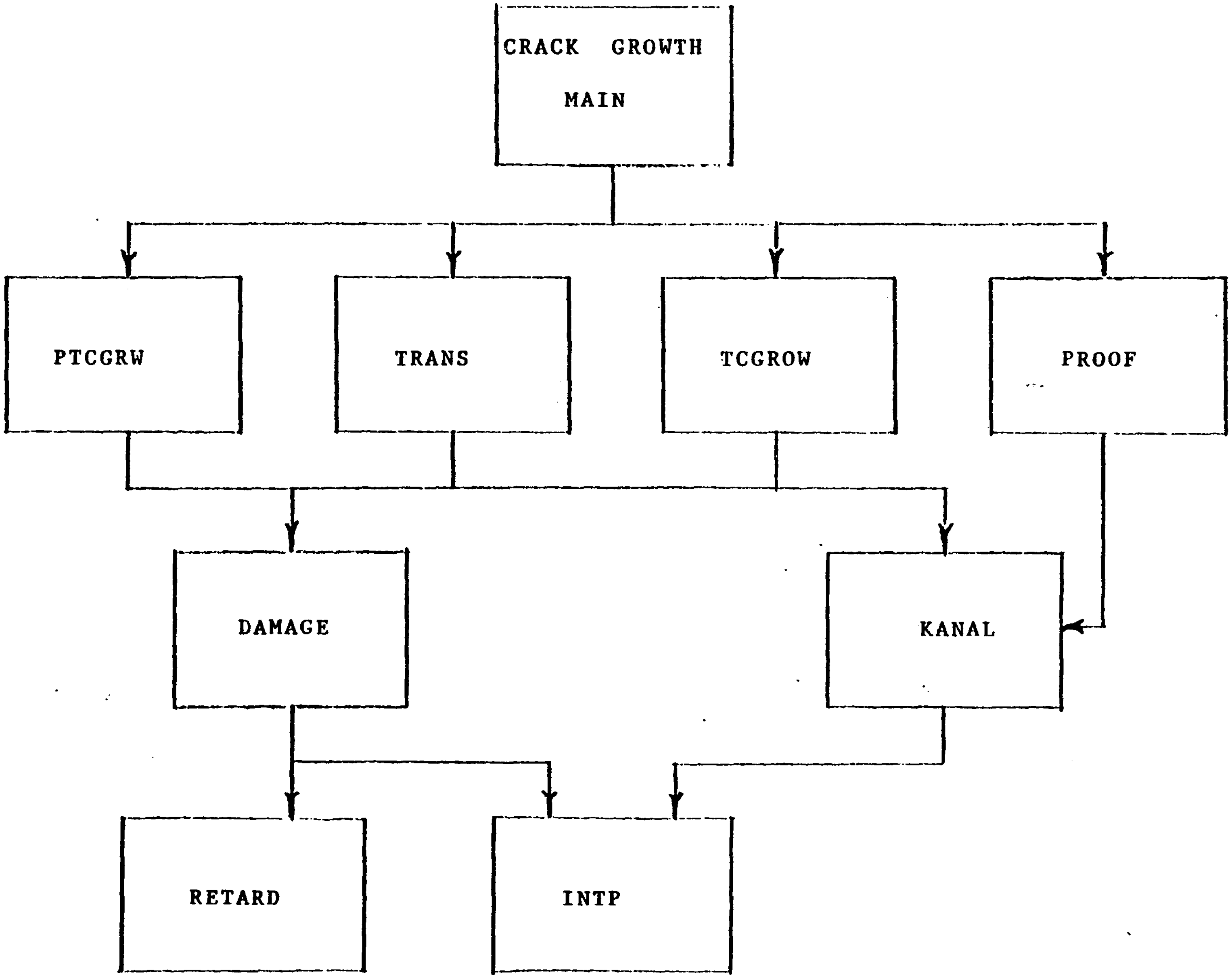


Figure 1 - Subroutines

TABLE I

SUBROUTINE FUNCTIONS

SUBROUTINE	FUNCTION
MAIN	Reads Input, Sequences Runs, Performs Design Iterations, Calls Proof Test Module, Calls Appropriate Crack Growth Module.
PROOF	Calculates initial flaw size based on proof test logic.
PTCGRW	Calculates crack growth for a part through crack.
TRANS	Calculates crack growth for a transitional crack.
TCGROW	Calculates crack growth for a through crack.
KANAL	Evaluates all stress intensity factors
DAMAGE	Calculates crack growth rates
INTP	Interpolates stress intensity or crack growth rate tables.
RETARD	Modifies input to damage to account for retardation effects.

In addition to the basic crack growth analysis program, a companion program which formats the crack growth data for plotting on the SC4020 plotter is included in the program package. The functional flow of the computer program package is indicated in Figure 2.

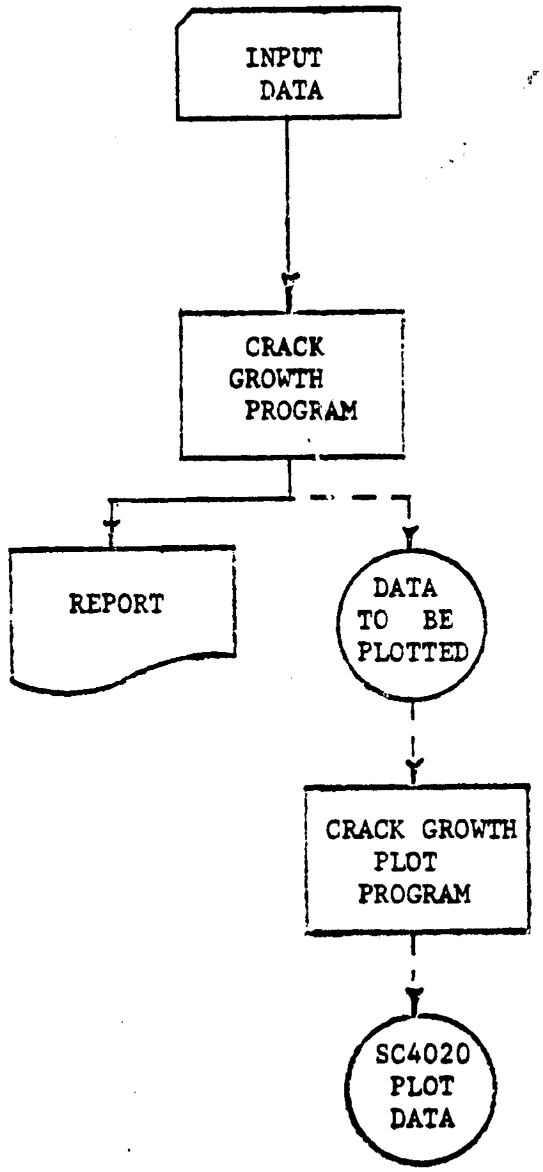


Figure 2 - Functional Flow

TECHNICAL APPROACH

The essence of the crack growth analysis procedure consists of:

1) Establishing an initial defect size: Either directly as input or as a result of proof test logic, or as a result of a design interation.
2) Considering each loading step in a load block in turn.
3) Evalutating stress intensity factors, using the stresses from the step under consideration.
4) Using these stress intensity factors (and previous loading history if retardation is considered) to calculate crack growth rate.
5) Consider a small amount of growth (1% of current crack size) and calculate the number of cycles it takes to grow that amount. If that amount exceeds the number of cycles not yet consumed in the step than only those remaining cycles are used and a corresponding crack growth increment is calculated.
6) Crack lengths are incremented, cycle count is incremented.
7) This process is continued until all cycles in the step are considered. The next step is then called. At the end of a block the first step is called again.
8) The calculation ends when:
   a) The critical stress intensity (either at the surface or at the depth of a crack) is exceeded.
   b) There is no crack growth ($<10^{-8}$ in.) for an entire block.
   c) The crack growth rate goes to infinity (when using the Forman equation for crack growth rate).

d) The maximum number of blocks is exceeded.

9) All input and all output data are in units compatible with Kips and inches. (e.g., Ksi, Ksi $\sqrt{in}$. and in/cycle.)

SUBROUTINES

The subroutine operations are each described below. Since MAIN serves primarily as a calling routine, it will be clearest if we describe MAIN last.

PROOF

The proof test module uses an iteration scheme of successive bisections and inverse parabolic interpolation to solve the nonlinear equations that arise in defining the crack size that will cause an applied stress intensity factor due to the proof load to equal the critical stress intensity factor. The critical condition is checked at both the depth and surface of a part through crack. The smallest crack size that produces criticality is the result. The critical stress intensity factors used for the proof test may be different than those used to predict the end of service life.

Thus, changes in environments and their concomitant changes in material properties may be accounted for (e.g., a cryogenic proof test). Either the crack depth (a), the surface length (c) or the shape (a/c) for a part through crack may be kept constant for the proof test calculation.

PTCGRW, TRANS, TCGROW

The subroutines PTCGRW, TRANS, and TCGROW calculate the crack growth increments, return to MAIN for information on the next loading step, consider when to end the calculation and transfer to each other (PTCGRW → TRANS → TCGROW) as required. For a part through crack PTCGRW performs these functions until TRANS is called. TRANS is called when the crack depth equals the plate thickness. TRANS performs these functions while the crack is transitioning to a through crack and calls TCGROW when the back surface length exceeds 95% of the front surface length. TCGROW performs these functions when the crack is a through crack and may be called by TRANS or in those cases when a through crack is considered initially it is called from MAIN.

KANAL

KANAL is a subroutine which returns factors, which when multiplied by the appropriate loading term yields stress intensity factors. Thus the loading input must be compatible with the crack configuration considered. For the configurations currently in the program

the corresponding name (KTYPO) and required load description are given in Table II. The geometrical arrangement of each configuration is given in Figure 3. Detailed descriptions of the stress intensity factors are given in the Appendix.

DAMAGE

The subroutine DAMAGE currently contains three equations and a provision for tabulated data for calculating crack growth rate. In all cases the independent variables are the effective stress intensity factor, KE, and the effective stress ratio, RE. When retardation is not used KE is simply the stress intensity range (KMAX - KMIN) and RE is simply the stress ratio. When retardation is used, KE and RE are calculated in RETARD.

The following equations all contain material property constants designated by D(NC,I,J). NC indicates whether the surface (NC = 1) or depth (NC = 2) is being considered. I distinguishes the various constants in that equation and indicates the order of the constant on the input cards. J is the material type number which is also input with end loading step. In order to call out the proper equation the corresponding equation name (NEQ) must be specified during input. Note that each material type could use a different NEQ.

TABLE II - Stress Intensity Factors in Kanal

KTYPO(1)	KTYPO(2)	Configuration	Load Description
1	1	PTC - center crack	Gross stress
1	2	None	
1	3	Single corner crack at hole	Gross stress
1	4	Double corner crack at hole	Gross stress
1	5	Single internal crack at hole	Gross stress
1	6	Double internal crack at hole	Gross stress
1	7	General tabular description	As required by tabular description
1	8	Single corner crack pin loaded lug	Pin load
1	9	Double corner crack pin loaded lug	Pin load
1	10	Single internal crack pin loaded lug	Pin load
1	11	Double internal crack pin loaded lug	Pin load
1	12	Corner crack at single notch	Gross stress
1	13	Corner cracks at double notch	Gross stress
1	14	Internal crack at single notch	Gross stress
1	15	Internal cracks at double notches	Gross stress

TABLE II - continued

KTYPO(1)	KTYPO(2)	Configuration	Load Description
1	16	Corner crack at shoulder	Gross stress
1	17	Internal crack at shoulder	Gross stress
2	1-17	Appropriate transition crack corresponding to through crack case - see KTYPO(1)=3 List	As described in corresponding KTYPO(1)=3 List
3	1	Center through Crack	Gross stress
3	2	Compact Specimen (ASTM E399-74)	Pin load
3	3 or 5	Single through crack at hole	Gross stress
3	4 or 6	Double through crack at hole	Gross stress
3	7	General tabular description	As required by tabular description
3	8 or 10	Single through crack - pin loaded lug	Pin load
3	9 or 11	Double through crack pin loaded lug	Pin load
3	12 or 14	Through crack at single notch	Gross stress
3	13 or 15	Through cracks at double notches	Gross stress
3	16 or 17	Through cracks at shoulder	Gross stress

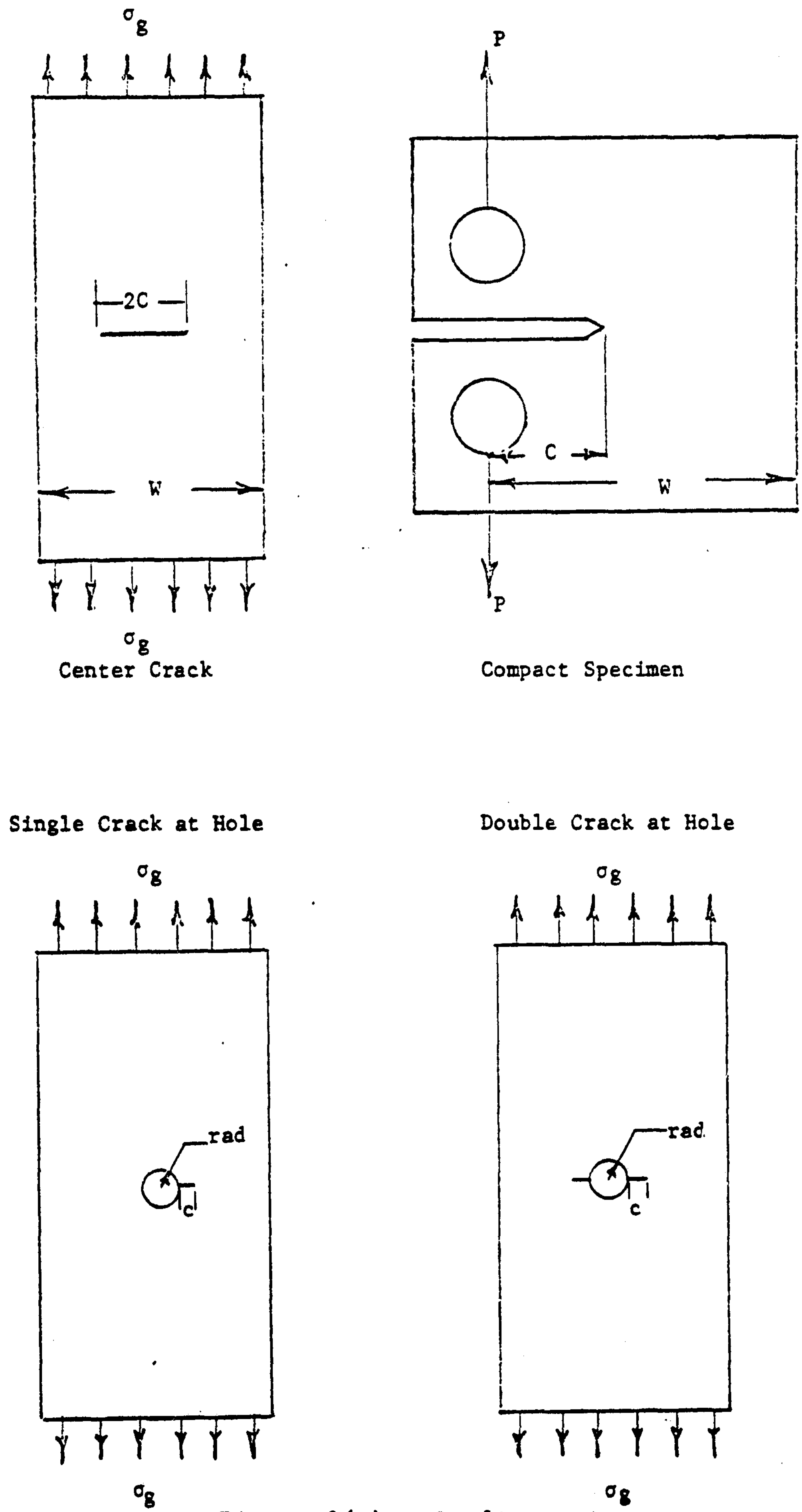
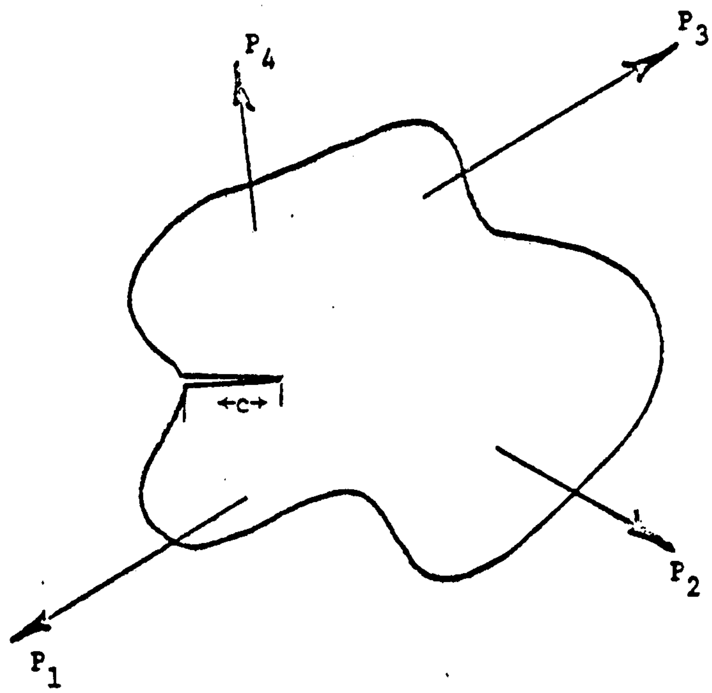


Figure 3(a) - Configuration Planforms



General Tabular Description

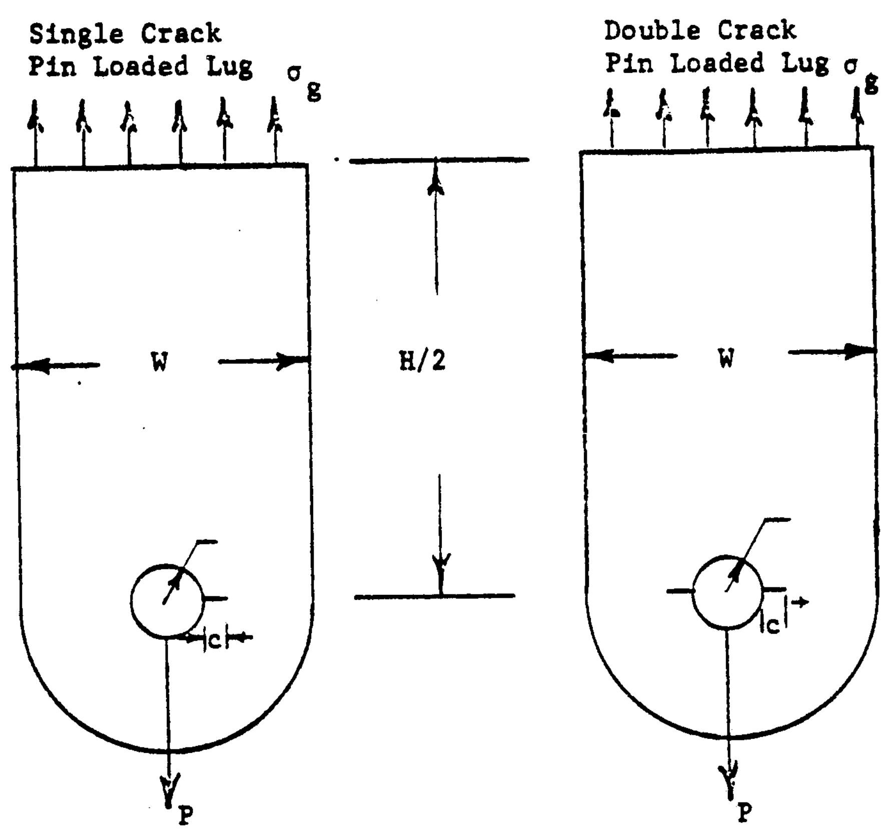
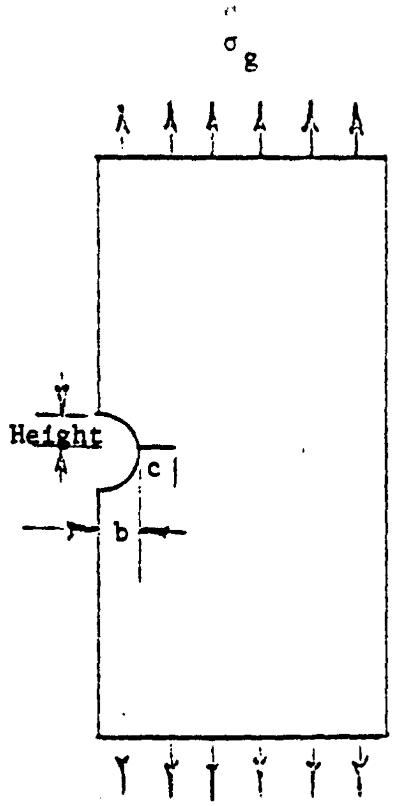
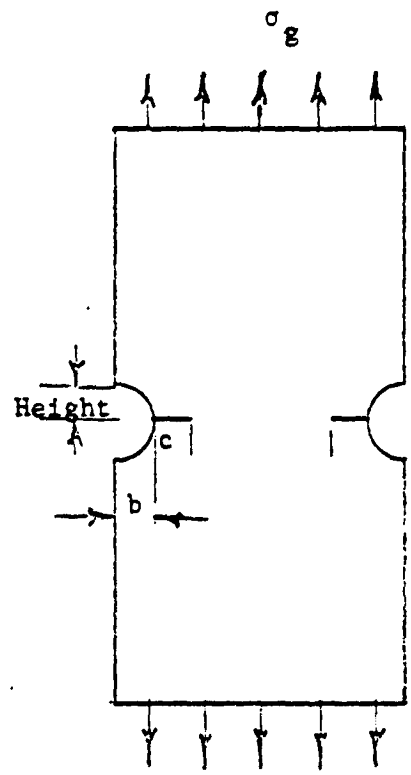


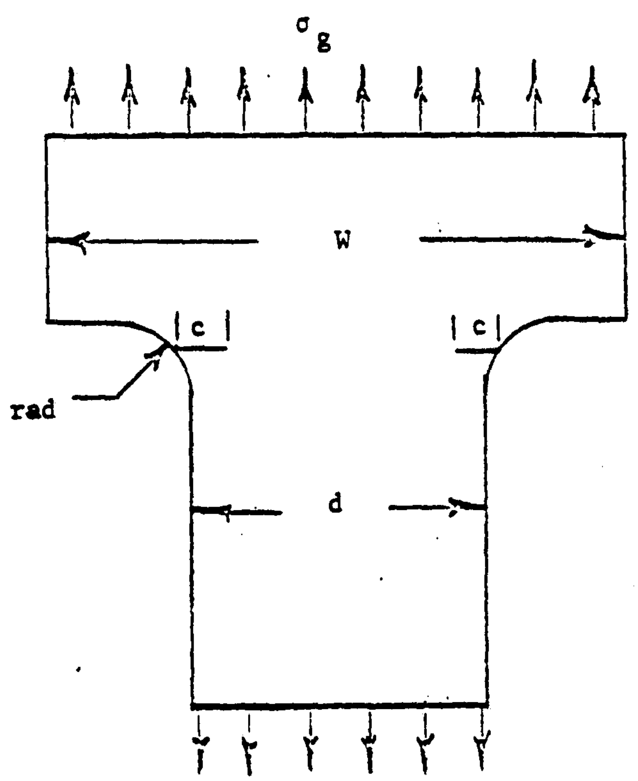
Figure 3(a) Cont.



Single Crack
at Notch



Cracks at
Double Notches



Cracks at Shoulder Radii

Figure 3(a) Cont.

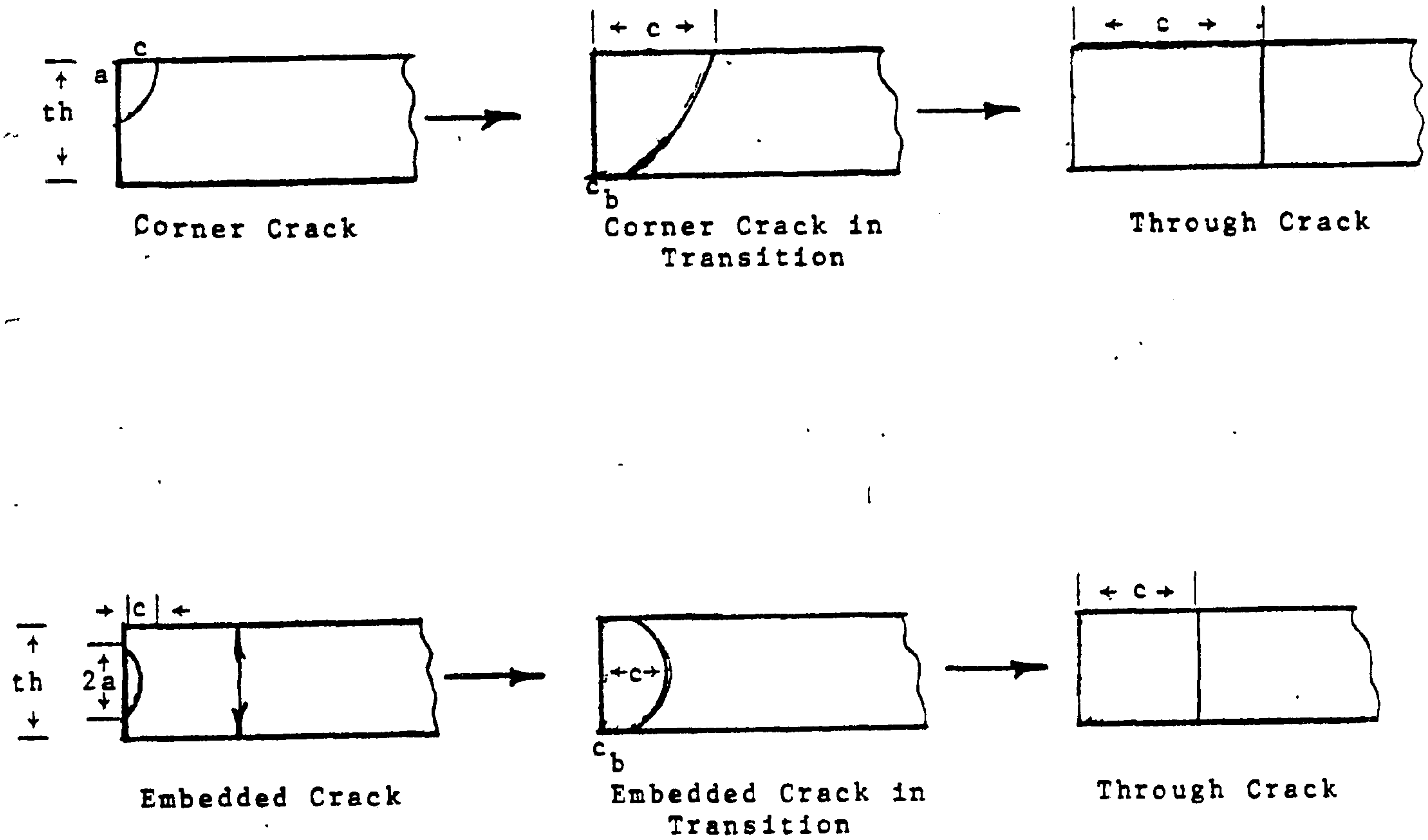


Figure 3b - Configuration Crossections

NEQ	EQUATION
1	Collipriest-Ehret
2	Paris
3	Forman
4	Tabulated Data

The use of "J" allows various loading steps to use different crack growth rate equations and thus variations in environment and crack growth phenomenon (fatigue or stress corrosion) can be accounted for.

The Collipriest-Ehret equation is:

$$\frac{da}{dn} = C_1 \text{ EXP}\left[C_2 \text{ TANH}^{-1}\right.$$

$$\left.\left(\frac{\ln(KE^2/(1-RE)\ D\ (NC,3,J)\ D\ (NC,4,J)}{\ln\ (1-RE)\ D\ (NC,3,J)/D\ (NC,4,J)}\right)\right]$$

$$C_2 = \ln\left(\frac{D(NC,3,J)}{D(NC,4,J)}\right)^{D\left(\frac{NC,2,J}{2}\right)}$$

$$C_1 = D(NC,1,J)\left[D(NC,3,J)\ D\ (NC,4,J)\right]^{D\left(\frac{NC,2,J}{2}\right)}$$

where

D(NC,1,J)	Crack growth rate coefficient
D(NC,2,J)	Dimensionless coefficient relating to midrange slope.
D(NC,3,J)	Critical stress intensity (upper asymptote)
D(NC,4,J)	Threshold stress intensity range (lower asymptote)

The Paris equation is:

$$\frac{da}{dn} = D(NC,1,J)\ KE^{D(NC,2,J)}$$

The Forman equation is:

$$\frac{da}{dn} = \frac{D(NC,1,J)\ KE^{D(NC,2,J)}}{(1-RE)\ D\ (NC,3,J)-KE}$$

where

D(NC,1,J)	Crack growth rate coefficient
D(NC,2,J)	Crack growth rate exponent
D(NC,3,J)	Critical stress intensity (upper asymptote)

Tabulated data is in input as a function of stress intensity range and stress ratio. If retardation is to be used, the variables are effective stress intensity range and effective stress ratio. The computer program performs linear interpolation in stress ratio and logarithmic interpolation in stress intensity range. This results in a "Paris Equation" fit between consecutive data points at a constant stress ratio. All stress ratios between the highest given in the Table and 1.0 use the crack growth rate at the highest stress ratio data supplied. The lowest stress ratio required by the loading spectrum must be within the range of the input data.

The format for crack growth data input is shown in Figure 4. For this mode of crack growth description only three material

types may be used. Thus, there is the possibility of supplying 6 Tables (surface/depth direction for each material type)

$$
\begin{array}{c|cccccc|}
 & RE(NT,1) & RE(NT,2) & \cdot & \cdot & \cdot & RE(NT,m) \\
\hline
KE(NT,1) & \frac{da}{dn}(NT,1,1) & & & & & \frac{da}{dn}(NT,1,m) \\
KE(NT,2) & & & & & & \\
\cdot & & & & & & \\
\cdot & & & & & & \\
\cdot & & & & & & \\
KE(NT,\ell) & & & & & & \frac{da}{dn}(NT,\ell,m) \\
\hline
\end{array}
$$

$\ell \leq 25$, $m \leq 25$

NT goes from 1 to 6 and is set automatically by the computer program and takes on values according to the following Table:

TABLE III

Material Type	Growth Direction	NT
1	Surface	1
1	Depth	2
2	Surface	3
2	Depth	4
3	Surface	5
3	Depth	6

RETARD

The subroutine RETARD currently contains three retardation models. In each of these a crack tip plastic zone r_y is calculated according to the equation

$$r_y = \frac{1}{(2\pi)Pz} \times \frac{K^2{max}}{\sigma_{ys}{}^2}$$

where Pz is a constant depending on the degree of plane stress versus plane strain. For plane stress Pz = 1. For plane strain Pz = 3.

The following is the retardation equation number for each retardation model.

NRET		
1	Willenborg Model	(Ref. 1)
2	Wheeler Model	(Ref. 2)
3	Grumman Closure Model	(Ref. 3)

The Willenborg retardation model calls for no constants other than Pz. The only material property input for this model is therefore

CR(NC,1,J) = Pz

The "Wheeler" model in this computer program is actually a variation of the model originally presented by Wheeler. Wheeler used a modification to the crack growth rate to produce a retardation effect and we have used a modification to the dependent

variable KE. If the Paris equation is used for crack growth rate the "Wheeler" model in this computer program is identical to the model presented in Ref. . The input material properties for this model are

CR(NC,1,J) = Pz

CR(NC,2,J) = m/n

where m is identical to the "m" used in Ref. and n is the exponent in the Paris equation (i.e., if the "Wheeler m" were 5 and the Paris "n" 4, the input value for CR(NC,2,J) is 1.25).

The details of the Grumman Closure model are too complex to be described here. The input is described below

Input Quantity	Name in Reference 3
CR(NC,1,J)	Pz
CR(NC,2,J)	C_f^{-1}
CR(NC,3,J)	C_{f_o}
CR(NC,4,J)	P
CR(NC,5,J)	NSAT
CR(NC,6,J)	ν_1
CR(NC,7,J)	B

INTP

INTP is a subroutine which interpolates tabular data. It is called from either KANAL or DAMAGÉ. When called from KANAL it will use the appropriate input Table and linearly inter-

polate in both (a) and (c) for part through cracks and linearly in (c) for through and transition cracks to obtain values of stress intensity factors. When called from DAMAGE it will use the appropriate input Table and interpolate linearly in stress ratio and logarithmically in stress intensity to obtain crack growth rates.

MAIN

MAIN reads all input data; controls calling sequences of subroutines PROOF, PTCGRW, TRANS and TCGROW; performs iterations on thickness or initial crack size to obtain desired crack growth lives; and controls output.

INPUT

There are 27 distinct data input card formats. These are described below and illustrated on pages 36 and 37. Pages 38 and 39 show when each card type is required. The superscript x designates fixed point numbers. All others are floating point.

CARD TYPE	FIELD	NOMENCLATURE	DESCRIPTION
1	1-80	TITLE	Any alphanumeric description of group of runs.
2	1-4	$NRUNS^x$	Total number of runs (one run corresponds to a unique set of input data.)
2	5-10	$NBLOCK^x$	Maximum number of blocks to be considered. Crack growth calculation ceases when the number of blocks exceeds this number.
2	11-14	$MBLOCK^x$	Block interval for which additional data will be printed (e.g., 3 would imply that blocks 3,6,9,12....etc. would have data printed out).
2	15-18	$MSTEP^x$	Step interval for which additional data will be printed (in the blocks called out above).
3	1-10	CSTRS	Constant multiplier for stress inputs. Allows stress spectrum to be varied by changing one number only. (e.g., one run with this constant 1.1, will show the effect of varying the stress 10%).
3	11-14	$NSUP^x$	Constant for suppression of retardation in crack growth analysis. If zero, retardation is not considered. If retardation is to be considered, constant must be 1.

CARD TYPE	FIELD	NOMENCLATURE	DESCRIPTION
3	15-18	NLOAD^{x}	Constant to indicate whether new load data is to be input. If zero, (or any number not equal to 1) load data will not be read in and load data from previous run will be used. If it is 1, card types 4 and 5 must follow.
3	19-22	NGEOM^{x}	Constant to indicate whether new geometry data is to be input. If zero (or any number other than 1) geometry data will not be read in and geometry data from previous run will be used. If it is 1, card types 6 and 7 must be read in.
3	23-26	NMAT^{x}	Constant to indicate whether new material data is to be input. If zero (or any number other than 1) material data will not be read in and material data from previous run will be used. If it is 1, card types 8, 9, 10, and 11, 12, 13, if needed must be read in.
3	27-30	ITERTP^{x}	Parameter that identifies variables for iteration to find geometry that survives the desired life. If ITERTP = 1, the thickness is varied. If ITERTP = 2, the surface crack length is varied and the crack depth (if a part through crack) is kept constant. If ITERTP = 3, the crack depth is varied and the surface length is kept constant. If ITERTP = 4, the crack shape is kept constant and both the crack depth and surface length are varied. Field may be left blank if ITER is zero (or blank).
3	31-34	ITER^{x}	Maximum number of iterations to find thickness or crack size that produces the desired life. May not exceed 10, may be left blank. Next two items on card three may be left blank, if ITER equals zero (or blank).

CARD TYPE	FIELD	NOMENCLATURE	DESCRIPTION
3	35-44	PIT	Parameter to control rate of convergence on design iteration. Usually set to exponential power in Paris crack growth equation for crack growth data. When other crack growth equation is used, approximate value of a "Paris exponent" will be sufficient. Must always be greater than 1.
3	45-54	BLIFE	Desired life in blocks.
3	55-58	NPROOF^x	Parameter that identifies variables in proof test logic. If zero (or blank) no proof test logic is performed. If 1, the crack surface and depth of a part through crack is varied and the shape held constant; if 2 the surface crack length of a through crack is varied; if 3 the crack depth of a part through crack is varied and the surface crack length is held constant; if 4 the surface crack length is varied and the depth is held constant.
3	59-62	IPLOT^x	Parameter to indicate whether output is to be plotted. If zero (or blank) data is not plotted. Any other value produces a plot of crack lengths versus blocks and cycles.
3	63-72	PCYC(1)	Interval in cycles between plotted data points. If zero, plotted points will correspond to tabular output.
4	1-4	NSTEP^x	Number of steps in load blocks.
4	5-8	IR^x	Zero if input format includes minimum stress, 1 if input format includes stress ratio.

CARD TYPE	FIELD	NOMENCLATURE	DESCRIPTION
4	9-18	SIGLM	Limit stress for additional end of life determination. Failure due to limit load does not terminate crack growth calculation.
5	1-10	SMAX	Maximum stress.
5	11-20	SMIN	Minimum stress if IR = 0, stress ratio of IR = 1.
5	21-30	UNIT	Number of cycles or alternate rate variable.
5	31-34	TYPE^{x}	Material property data type to be used.
6	1-4	KTYPO(1)^{x}	Initial crack type; 1 corresponds to a part through crack; 2 corresponds to a transition crack and 3 corresponds to a through crack.
6	5-8	KTYPO(2)^{x}	Parameter which specifies geometry (e.g., corner crack at hole) See page 17 for geometry descriptions.
7	1-10	W	Plate width.
7	11-20	TH	Plate thickness
7	21-30	CO	Initial half surface length for part through crack or through crack. Corresponds to initial value of "C" in Figure 3.
7	30-40	AO	Initial crack depth for a part through crack. May be left zero for through cracks.
7	41-50	H	Configuration dimension as described on pages 17 through 19.

CARD TYPE	FIELD	NOMENCLATURE	DESCRIPTION
7	51-60	RAD	Hole or notch radius or notch height as described on pages 17 through 19.

Cards 8-14 are only used when KTYPO(2) is set equal to 7.

CARD TYPE	FIELD	NOMENCLATURE	DESCRIPTION
8	1-4	NKTMX[x]	Number of sets of stress intensity tables. For PTC there are 2 tables per set. The first table of each set is for surface stress intensity factors. The second table is for the stress intensity at the depth. See Appencix for a description of the tables. For through cracks there is one table per set. Three is the maximum number of sets allowed.
9	1-10	C1(NT,I)	Values of surface crack length for table NT surface stress intensity factor. Maximum number of values is 25.
	78-80		If letters "END" appear in this field the value in field 1-10 is the last entry in the list.
10	1-10	A1(NT,J)	Values of crack depth for table NT of surface stress intensity factor. Maximum number of values is 25. These are not read in if crack is a through crack.
	78-80		If letters "END" appear in this field the value in field 1-10 is the last entry in the list.
11	1-10 11-20 etc.	F1(NT,I,J)	Table of surface stress intensity factor coefficients at above crack lengths. Each series of cards is for a constant value of surface crack length (e.g., if the configuration is a through crack each card will contain one table value).
12	1-10	C2(NT,I)	Values of surface crack length for table NT depth stress intensity factor. Maximum number of values is 25.
	78-80		If letters "END" appear in this field the value in field 1-10 is the last entry in the list.

CARD TYPE	FIELD	NOMENCLATURE	DESCRIPTION
13	1-10	A2(NT,J)	Values of crack depth for table NT of depth stress intensity factor. Maximum number of values is 25. These are not read in if crack is a through crack.
	78-80		If letters "END" appear in this field the value in field 1-10 is the last entry in the list.
14	1-10 11-20 etc.	F2(NT,I,J)	Table of depth stress intensity factor coefficients at above crack lengths. Each series of cards is for a constant value of depth crack length (e.g., if the configuration is a through crack each card will contain one table value).
15	1-4	NJ[x]	Number of material property types.
16	1-10	SIGYS	Yield stress.
16	11-14	NEQ[x]	Equation to be used for crack growth. 1 = Collipriest-Ehret, 2 = Paris, 3 = Forman, 4 = table.
16	15-18	NRET	Model to be used for retardation 0 = none, 1 = Willenborg, 2 = Wheeler, 3 = Grumman Closure (not debugged).
16	19-22	NDUP[x]	Constant to indicate whether crack growth properties are the same in depth and surface directions. If constant = 1, they are not and two sets of D's and CR's (see cards 20, 21, 22, 24, and 26) must be input.
16	23-32	KCRC	Critical stress intensity in surface direction (upper cutoff).
16	33-42	KOC	Threshold stress intensity in surface direction (lower cutoff).
16	43-52	KCRA	Critical stress intensity in depth direction. Need not be input if crack is a through crack.

CARD TYPE	FIELD	NOMENCLATURE	DESCRIPTION
16	53-62	KOA	Threshold stress intensity in depth direction. Need not be input if crack is a through crack
		Cards 17 - 22 only used when NEQ = 4	
17	1-10	KE(NT,I)	Values of stress intensity factor range for table of crack growth rates. Maximum number is 25.
	78-80		If letters "END" appear in this field, value in field 1-10 is last entry in list.
18	1-10	RE(NT,J)	Values of stress ratios for crack growth rate table. At least one is required. Maximum number is 25.
	78-80		If letters "END" appear in this field, value in field 1-10 is last entry in list.
19	1-10 11-20 etc.	DCDN(NT,I,J)	Values of surface crack growth rate corresponding to above stress intensity values and stress ratios. Each series of cards is for a constant value of stress intensity range (e.g., if 4 values of RE were to be used, each card type 15 would have 4 entries).
20	1-10	KE(NT,I)	Values of stress intensity factor range for table of crack growth rates. Maximum number is 25.
	78-80		If letters "END" appear in this field, value in field 1-10 is last entry in list.
21	1-10	RE(NT,J)	Values of stress ratios for crack growth rate table. At least one is required. Maximum number is 25.
	78-80		If letters "END" appear in this field, value in field 1-10 is last entry in list.

CARD TYPE	FIELD	NOMENCLATURE	DESCRIPTION
22	1-10 11-20 etc.	DADN(NT,I,J)	Values of depth crack growth rate corresponding to above stress intensity values and stress ratios. Each series of cards is for a constant value of stress intensity range (e.g., if 4 values of RE were to be used, each card type 15 would have 4 entries).
23	1-10	D(1,I,J)	Constants in crack growth equations-surface direction. See text for description of constants.
	78-80		If letters "END" appear in this field, value in field 1-10 is last entry in list.
24	1-10	D(2,I,J)	Constants in crack growth equation-depth direction. If NDUP ≠ 1, card is not used. See text for description of constants.
	78-80		If letters "END" appear in this field, value in field 1-10 is last entry in list.
25	1-10	CR(1,I,J)	Constants in retardation equation-surface direction. See text for description of constants.
	78-80		If letters "END" appear in this field, value in field 1-10 is last entry in list.
26	1-10	CR(2,I,J)	Constants in retardation equation-depth direction. If NDUP ≠ 1, card is not used. See text for description of constants.
	78-80		If letters "END" appear in this field, value in field 1-10 is last entry in list.
		Card 27 is not used if NPROOF = 0	
27	1-10	FIXED	Value of quantity which remains constant during proof test evaluation.
27	11-20	KCPRF	Value of critical surface stress intensity factor for proof test.

CARD TYPE	FIELD	NOMENCLATURE	DESCRIPTION
27	21-30	KAPRF	Value of critical stress intensity at depth for proof test.
27	31-40	XLOW	Lower bound on variable in proof test (smallest expected value on crack size or shape).
27	41-50	XUP	Upper bound on variable in proof test (largest expected value on crack size or shape).
27	51-60	PROOFX	Proof stress (or load).
27	61-70	IEND	Number of iterations to find crack size in proof test. If zero or blank, default condition sets number of iterations to 100.

All Numeric Fields are in either E10.0, I4 or I6 Formats

Card Type	Fields
1	TITLE
2	NRUNS, NBLOCK, MBLOCK, MSTEP
3	CSTRS, NSUP, NLOAD, NGEOM, NMAT, ITERTP, ITER, PIT, BLIFE, NPROOF, IPLOT, PCYC(1)
4	NSTEP, IR, SIGLM
5	SMAX, SMIN, UNIT, TYPE
6	KTYPO(1), KTYPO(2)
7	W, TH, CO, AO, H, RAD
8	NKTMX
9	C1(NT,I) — last type 9 card only → END
10	A1(NT,J) — last type 10 card only → END
11	F1(NT,I,J) . . . . F1(NT,I,J) . . . .
12	C2(NT,I) — last type 12 card only → END
13	A2(NT,J) — last type 13 card only → END

Card Type

All Numeric Fields are in either E10.0, I4 or I6 Formats

Card Type	Col. 1–10	11–20	21–30	31–40	41–50	51–60	61–70	71–80
14	F2(NT,I,J)			F2(NT,I,J)				
15	NI							
16	SIGYS	NEQ / NRET / NDUP	KCRC	KOC	KCRA	KQA		
17	KE(NT,I)						last type 17 card only → END	
18	RE(NT,J)						last type 18 card only → END	
19	DCDN(NT,I,J)			DCDN(NT,I,J)				
20	KE(NT,I)						last type 20 card only → END	
21	RE(NT,J)						last type 21 card only → END	
22	DADN(NT,I,J)			DADN(NT,I,J)				
23	D(1,I,J)						last type 23 card only → END	
24	D(2,I,J)						last type 24 card only → END	
25	CR(1,I,J)						last type 25 card only → END	
26	CR(2,I,J)						last type 26 card only → END	
27	FIXED	KCPRF	KAPRF	XLOW	XUP	PROOFX	IEND	

↑ Card Type

CARD TYPE	FIELD	WHEN INPUT DATA REQUIRED	
1	1-80	Once for each session	
2	1-16	Once for each session.	
3	1-26	Once for each run.	
3	27-54	Whenever an iteration on thickness to meet design life is desired.	
3	55-58	Whenever proof test logic is used.	
3	59-72	Whenever plotted output is required.	
4	1-18	Whenever NLOAD = 1.	
5	1-34	NSTEP times when NLOAD = 1.	
6	1-8	Whenever NGEOM = 1.	
7	1-60	Whenever NGEOM = 1.	
8	1-4	Whenever KTYPO(2) = 7.	
9	1-10	*Whenever KTYPO(2) = 7.	
10	1-10	*Whenever KTYPO(2) = 7 and KTYPO(1) = 1.	
11	1-80	*Whenever KTYPO(2) = 7	
12	1-10	*Whenever KTYPO(2) = 7 and KTYPO(1) = 1.	NKTMX Times
13	1-10	*Whenever KTYPO(2) = 7 and KTYPO(1) = 1.	
14	1-80	*Whenever KTYPO(2) = 7 and KTYPO(1) = 1.	
15	1-4	Whenever NMAT = 1.	

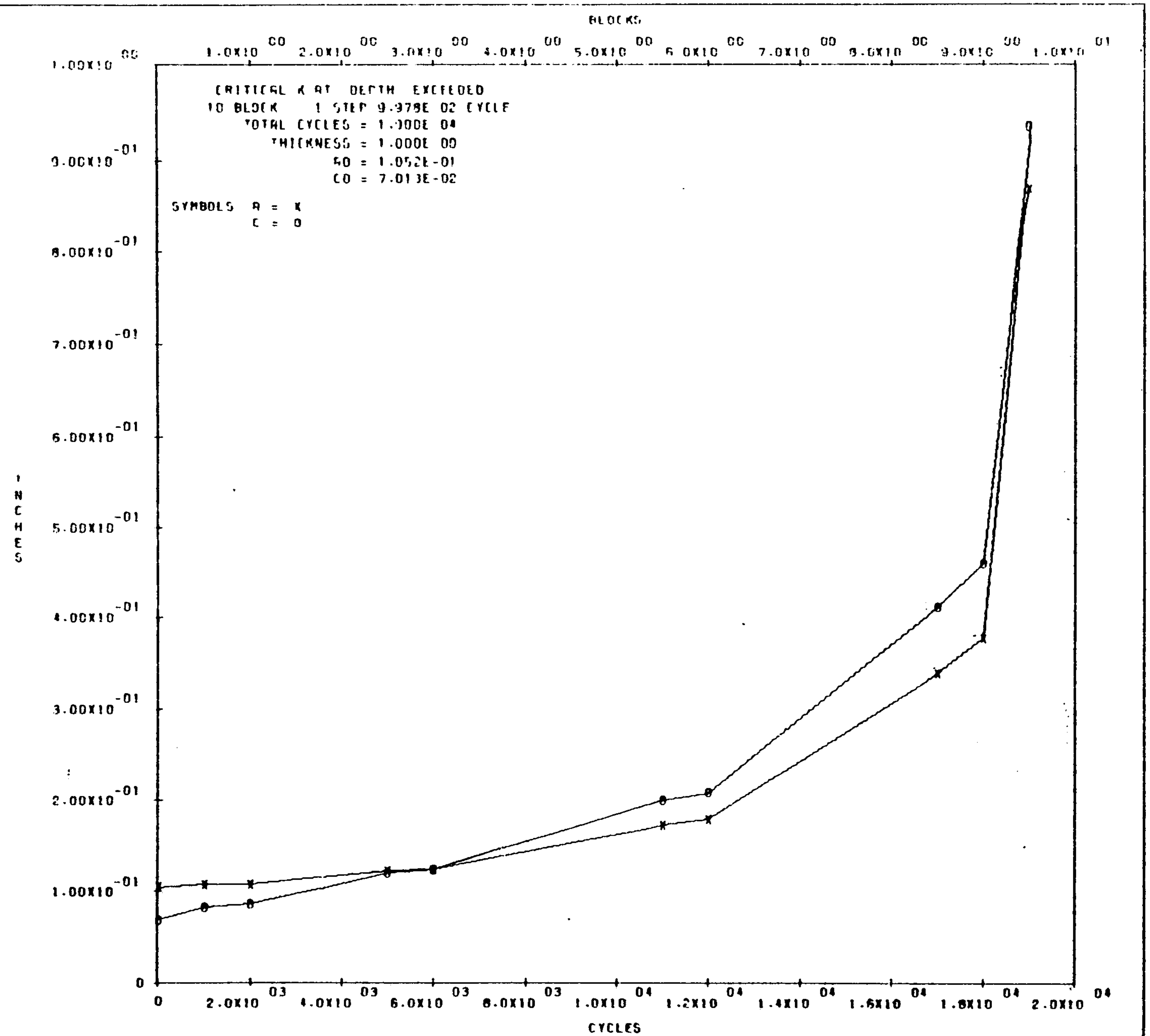
CARD TYPE	FIELD	WHEN INPUT DATA REQUIRED	
16	1-62	*Whenever NMAT = 1.	
17	1-10	*Whenever NEQ = 4.	
18	1-10	*Whenever NEQ = 4.	
19	1-80	*Whenever NEQ = 4.	
20	1-10	*Whenever NEQ = 4 and NDUP = 1.	
21	1-10	*Whenever NEQ = 4 and NDUP = 1.	
22	1-8	*Whenever NEQ = 4 and NDUP = 1.	NJ Times
23	1-10	*Whenever NEQ ≠ 4 and NMAT = 1.	
24	1-10	*Whenever NEQ ≠ 4 and NDUP = 1 and NMAT = 1.	
25	1-10	*Whenever NEQ ≠ 4 and NMAT = 1 and NRET ≠ 0.	
26	1-10	*Whenever NEQ ≠ 4 and NMAT = 1 and NRET ≠ 0.	
27	1-70	Whenever NPROOF ≠ 0	

* Indicates card types that may be repeated.

CONTROL OF OUTPUT

In addition to information describing the input data and final fracture, the computer program output consists of crack lengths, stress intensity factors, crack growth rates and cycle counts. These are printed out for the first and last cycle in the step. This data is always printed for each step of the first block encountered in any of the growth modules (PTCGRW, TRANS or TCGROW). This data may also be printed out for additional blocks and steps as desired by the user. These additional blocks and steps are controlled by specifying the increment for blocks and steps for which print out will be made by MBLOCK and MSTEP respectively. Thus, if every step in every other block is wanted, MBLOCK is set equal to 2 and MSTEP is set equal to 1.

Plotted output is supplied when IPLOT is a value not equal to one. Typical plotted output is presented in the Appendix. The spacing of each data point in the plot is set by the user through PCYC(1). PCYC(1) is the increment in cycles between successive data points. If PCYC(1) is zero, the plotted data points will correspond to the tabulated data points as described above. Sample output is shown in Figure 4.



CHECK ON PART-THRU CRACK INTERPOLATION

Figure 4 - Sample Plotted Output

INPUT FOR ADDITIONAL RUNS

A full set of input data is not necessary for each additional run. The use of a stress multiplier constant (CSTRS) allows all the stress to be varied by a constant percentage without inputting any additional input cards other than card type 3. If the stresses are to be used directly as they are on card type 5, CSTRS is input as 1.

The input constant NSUP allows retardation to be suppressed on subsequent runs. That is if a run is made that considers retardation, the following run will perform the same analysis without retardation if NSUP = 0. When retardation is considered NSUP must be set equal to 1. Obviously the order of running the cases must be retarded, followed by unretarded.

In order to control whether loading data, geometry data, or material properties are to be read in for a particular run, the constants NLOAD, NGEOM, NMAT must be input. If data is to be read in, the appropriate constant must be 1, it it is not to be read in, the appropriate constant is 0. If data is not read in, data from the previous run is used. Obviously, for the first run NLOAD, NGEOM AND NMAT must all be 1.

ITERATION ON THICKNESS AND INITIAL CRACK SIZE

For a given design life (in blocks) the computer program will search for the thickness or initial crack size which will meet that life requirement. The number of iterations attempted is input by the user. The maximum that this may be is ten. This computer program ceases its search when the allowed number of iterations is exceeded or the computed life lies between 100% and 105% of the design life. Life is arbitrarily defined as the number of blocks completed plus the number of steps completed/ total number of steps + cycles completed in the current step/total number of cycles in the step.

In addition to inputting the number of iterations and the design life, an exponent which will control the rate of convergence to the correct thickness or initial crack size must be inserted. When the Paris equation is used with zero threshold for a through the thickness crack, the use of the exponent of the Paris equation for the convergence parameter should result in a convergence to the correct solution in a single cycle. Any constant equal to or greater than the "Paris coefficient" should insure convergence.

PROOF TEST LOGIC

For given values of the fracture toughness and applied proof test load, the computer program will find the largest crack size that will not fail due to the proof load. Since the applied stress intensity factor for a part through crack depends on two geometric variables, the crack depth and surface crack length; one variable must be fixed by the user and the computer program will find the critical value for the other variable. Either the crack depth, surface crack length or crack shape (a/c) may be fixed.

REFERENCES

1) Willenborg, R. M., Engle, R. M., and Wood, H. A., "A Crack Growth Retardation Model Using an Effective Stress Concept," AFFDL Technical Memorandum 71-1-FBN.

2) Wheeler, D. E., "Crack Growth Under Spectrum Loading," General Dynamics, Fort Worth Division, FZM 5602 June, 1970.

3) Bell, P. D., and Creager, M. "Crack Growth Analysis for Arbitrary Spectrum Loading," AFFDL-TR-74-129, Vol. 1, Final Report: June, 1972 - Oct., 1974.

APPENDIXES

CRACK GROWTH RATE DATA

The following data for use in the Collipriest/Ehret equation (NEQ = 1) is typical data for the materials listed. The data is included for example purposes only and caution is advised with regard to design implications of the data presented. The crack growth rate is in in/cycle and the stress intensity factor is in Ksi $\sqrt{in.}$

Material	D(NC,1,J) Coefficient	D(NC,2,J) Relates to Midrange Slope	D(NC,3,J) Upper Asymptote	D(NC,4,J) Lower Asymptote
2024-T851	1.6×10^{-9}	3.45	38.0	3.4
2124-T851	3.3×10^{-10}	4.0	31.0	3.5
2219-T87 (70°F)	2.2×10^{-9}	3.3	40.0	5.5
2219-T87 (-320°F)	8.9×10^{-12}	4.82	50.0	5.5
7075-T6	4.4×10^{-8}	2.53	33.0	3.0
7075-T76	6.3×10^{-9}	3.0	30.0	3.0
7075-T73	1.07×10^{-8}	2.67	40.0	3.5
Ti-6Al-4VSTA	6.8×10^{-10}	3.3	50.0	7.0
Ti-6AL-4V Annealed	5.7×10^{-10}	3.18	84.0	6.0
Inconnel 718 (STA)	4.0×10^{-10}	2.7	115.0	15.0
D 6AC	7.5×10^{-10}	2.74	90.0	6.0

APPENDIX B

CRACK GROWTH ANALYSIS EXAMPLES

A series of five computer sessions are presented below. The flexibility and generality of the MSFC crack growth program make it impractical to present all possible variations here. However, the following examples which include many multiple run sessions cover a broad spectrum of the program's capability.

In addition to showing the card images for each example input, we have included the card type represented by each line in the input data.

Example 1 - 2219 Al 70 deg and -320 deg part-thru and center crack.

Sample input data for a series of two runs is given on page B-6. The first run is a part through crack subjected to a series of two loads of 1000 cycles each. The material properties associated with each load level are different so as to model the effect of temperature variations. The second run is the same except that the initial crack configuration is a through the thickness center cracked panel. No output beyond the normally supplied out is requested for these runs. The output is shown on pages B-7 through B-10.

Example 2 - D6AC - Retard/No Retard/with DaDt

A second example consisting of a series of three runs is presented on pages B-12 through B-21 Page B-11 is the input for these three runs. For these runs data on every other block is requested and the output was rather extensive. All the information was not needed here and therefore only the first and last page of output of those runs discussed are reproduced. Note that only the third run requires 2 material property types, but that both sets of material data are read in the first run. This simplifies the data input by making it unnecessary to input any material property data for run 3.

The first run has two loading steps, calls for a retardation model (Willenborg) and requests a maximum of three iterations to find a thickness compatable with the design life. A rather low (compared to the "Paris exponent") convergence exponent of 2 was used. The output for the first iteration is shown on pages B-13 through B-14 and the report on the iteration is shown on page B-15 Due to the use of the excessively low value of the convergence exponent, the thickness has not converged to the appropriate value. Note, however, that the information is still quite useful and that a simple hand plot of the result will show the correct thickness.

In the second run retardation was suppressed and no iteration was requested. Note that the life for a thickness of .5 inches

goes from 194 blocks with retardation to 114 blocks without retardation.

In the third run a step which simulated a 480 second hold at a constant load with a resulting sustained load crack growth was included. The crack growth model was assumed to follow a "Paris" format (NEQ = 2) with an exponent of 1 and an appropriate constant was assumed. As can be seen by the results, the life was reduced further under these assumptions.

Example 3 - D6AC Iteration on Crack Size/Proof Test.

In this two run example, a part through crack under a single level of loading was considered. The output requested was for every tenth block. In the first run a design iteration in crack size in which the crack shape remains constant was called for. In this case the convergence parameter chosen was appropriate and the design conditions were met in the first iteration. The output for the initial run, the first iteration and the iteration report are given on pages B-23 through B-26.

In the second run a proof loading was considered. The output for this is given on pages B-27 and B-28.

Example 4 - D6AC Pin Loaded Lug with Plotting.

In this single run session a pin loaded lug with two internal cracks was considered. Plotted output every 500 (nominal)

cycles was requested. Tabulated data every 10 blocks was also requested. Note that the input loading is 50 Kips (not 50 Ksi). As can be seen by the data output the cracks transition to through cracks halfway through their crack growth lives. The data to be plotted is shown on page B-34 The first column is "a", the second "c" and the third is the number of cycles.

Example 5 - Tabular Input Examples
In this example; three runs, each requiring tabular input data of different types is shown. In the first run a part through crack using the solutions for the stress intensity factor which are in the program was considered. However, the crack growth rate data was input as a table. Three values of stress ratio and eight values of stress intensity range were used.

In the second run, the same material properties as in the first run were considered but the geometry was changed to a through crack that required a tabular input. The tabular input chosen was picked to simulate the consideration of two factors (e.g., the effect of a stiffener and the effect of a finite width) the first table decreases and then increases, the second table increases monotonically. Note that the number of tables input (2) is determined by the numerical value on the type 8 card and the

and the fact that this is a through crack.

In the last example, the geometry is changed once again. This time we have a part through crack that requires tabular input. Note that although the type 8 card value of NKTMX is 1, two tables are required since this is a part through crack.

```
          1111111111222222222233333333334444444444555555555566666666667777777778
 12345678901234567890123456789012345678901234567890123456789012345678901234567890

 1 2219 AL   70 DEG AND -320 DEG  PART-THRU CRACK AND CENTER CRACK
 2     2    100 100     1
 3  1.             0    1    1    1
 4     2    0  30.
 5  30.          0.          1000.         1
 5  30.          0.          1000.         2
 6     1    1
 7  99.          1.          .2          .3
15     2
16  50.             1    0    0 40.       3.5          40.          3.5       Run 1
23     2.2E-09
23     3.3
23     40.                                                                   END
23     3.5
16  70.             1    0    0 50.       5.5          50.          5.5
23     8.9E-12
23     4.82
23     50.                                                                   END
23     5.5
 3  1.             0    0    1    0
 6     3    1                                                            Run 2
 7  6.           .5          .25

          1111111111222222222233333333334444444444555555555566666666667777777778
 12345678901234567890123456789012345678901234567890123456789012345678901234567890
```

Card Type

Column Number

RUN 1 OF 2 RUNS 2219 AL 70 DEG AND -320 DEG PART-THRU CRACK AND CENTER CRACK

LOAD INPUT DATA

STRESS FACTOR 1.000E 00
LIMIT STRESS 3.000E 01

STEP	MAX STRESS	MIN STRESS	UNITS(CYCLES)	MATERIAL TYPE
1	3.000E 01	0.0	1.000E 03	1
2	3.000E 01	0.0	1.000E 03	2

GEOMETRY INPUT DATA

CRACK TYPE	PTC = 1
WIDTH	9.900E 01
ADDITIONAL DIMENSION	0.0
RADIUS/NOTCH DEPTH	0.0
THICKNESS	1.000E 00
CRACK DEPTH	3.000E-01
HALF CRACK LENGTH	2.000E-01

MATERIAL INPUT DATA

MATERIAL TYPE	YIELD STRENGTH	GROWTH EQUATION	RETARDATION MODEL	CRITICAL STRESS INTENSITY (SURFACE)	THRESHOLD STRESS INTENSITY (SURFACE)	CRITICAL STRESS INTENSITY (DEPTH)	THRESHOLD STRESS INTENSITY (DEPTH)
1	5.000E 01	1	0	4.000E 01	3.500E 00	4.000E 01	3.500E 00
2	7.000E 01	1	0	5.000E 01	5.500E 00	5.000E 01	5.500E 00

==============EQUATION CONSTANTS=============

CONSTANT NUMBER	MATERIAL TYPE	CRACK GROWTH RATE SURFACE	CRACK GROWTH RATE DEPTH	RETARDATION MODEL SURFACE	RETARDATION MODEL DEPTH
1	1	2.200E-09	2.200E-09	0.0	0.0
2	1	3.300E 00	3.300E 00	0.0	0.0
3	1	4.000E 01	4.000E 01	0.0	0.0
4	1	3.500E 00	3.500E 00	0.0	0.0
1	2	8.900E-12	8.900E-12	0.0	0.0
2	2	4.820E 00	4.820E 00	0.0	0.0
3	2	5.000E 01	5.000E 01	0.0	0.0
4	2	5.500E 00	5.500E 00	0.0	0.0

RUN 1 2219 AL 70 DEG AND -320 DEG PART-THRU CRACK AND CENTER CRACK

CRACK IS A PART THRU CRACK

BLOCK	STEP	CYCLES	HALF SURFACE CRACK LENGTH (IN)	CRACK DEPTH (IN)	KMAX-SURFACE (KSI ROOT-IN)	KMAX-DEPTH (KSI ROOT-IN)	SURFACE GROWTH RATE (IN/CYCLE)	DEPTH GROWTH RATE (IN/CYCLE)
1	1	0.0	2.000E-01	3.000E-01	2.051E 01	1.621E 01	5.407E-05	2.214E-05
1	1	1.000E 03	2.637E-01	3.269E-01	2.224E 01	1.829E 01	7.672E-05	3.440E-05
1	2	0.0	2.637E-01	3.269E-01	2.237E 01	1.847E 01	2.958E-05	1.132E-05
1	2	1.000E 03	2.954E-01	3.395E-01	2.304E 01	1.932E 01	3.448E-05	1.414E-05

LIMIT LOAD FRACTURE OCCURS IN THE 3 BLOCK 1 STEP AFTER 6.139E 02 CYCLES

CRITICAL K AT DEPTH HAS BEEN EXCEEDED IN THE 3 BLOCK AND THE 1 STEP AFTER 6.139E 02 CYCLES

RUN 2 OF 2 RUNS 2219 AL 70 DEG AND -320 DEG PART-THRU CRACK AND CENTER CRACK

LOAD INPUT DATA

STRESS FACTOR 1.000E 00
LIMIT STRESS 3.000E 01

STEP	MAX STRESS	MIN STRESS	UNITS(CYCLES)	MATERIAL TYPE
1	3.000E 01	0.0	1.000E 03	1
2	3.000E 01	0.0	1.000E 03	2

GEOMETRY INPUT DATA

CRACK TYPE	TC = 1
WIDTH	6.000E 00
ADDITIONAL DIMENSION	0.0
RADIUS/NOTCH DEPTH	0.0
THICKNESS	5.000E-01
HALF CRACK LENGTH	2.500E-01

B-9

MATERIAL INPUT DATA

MATERIAL TYPE	YIELD STRENGTH	GROWTH EQUATION	RETARDATION MODEL	CRITICAL STRESS INTENSITY (SURFACE)	THRESHOLD STRESS INTENSITY (SURFACE)	CRITICAL STRESS INTENSITY (DEPTH)	THRESHOLD STRESS INTENSITY (DEPTH)
1	5.000E 01	1	0	4.000E 01	3.500E 00	4.000E 01	3.500E 00
2	7.000E 01	1	0	5.000E 01	5.500E 00	5.000E 01	5.500E 00

		--------------EQUATION CONSTANTS--------------			
CONSTANT NUMBER	MATERIAL TYPE	CRACK GROWTH RATE SURFACE	CRACK GROWTH RATE DEPTH	RETARDATION MODEL SURFACE	RETARDATION MODEL DEPTH
1	1	2.200E-09	2.200E-09	0.0	0.0
2	1	3.300E 00	3.300E 00	0.0	0.0
3	1	4.000E 01	4.000E 01	0.0	0.0
4	1	3.500E 00	3.500E 00	0.0	0.0
1	2	8.900E-12	8.900E-12	0.0	0.0
2	2	4.820E 00	4.820E 00	0.0	0.0
3	2	5.000E 01	5.000E 01	0.0	0.0
4	2	5.500E 00	5.500E 00	0.0	0.0

RUN 2 2219 AL 70 DEG AND -320 DEG PART-THRU CRACK AND CENTER CRACK

CRACK IS A THROUGH CRACK

BLOCK	STEP	CYCLES	HALF CRACK LENGTH (IN)	KMAX (KSI ROOT-IN)	CRACK GROWTH RATE (IN/CYCLE)
1	1	0.0	2.500E-01	2.677E 01	1.994E-04

LIMIT LOAD FRACTURE OCCURS IN THE 1 BLOCK 1 STEP AFTER 3.691E 02 CYCLES

CRITICAL K AT SURFACE HAS BEEN EXCEEDED IN THE 1 BLOCK AND THE 1 STEP AFTER 3.691E 02 CYCLES

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            11111111112222222222333333333344444444445555555555666666666677777777778
   12345678901234567890123456789012345678901234567890123456789012345678901234567890
 1 DEAC-RETARD / NO RETARD / WITH DADT
 2    3   500   2   1
 3  1.          1   1   1   1   1   3 2.        200.
 4    2   0 180.
 5  150.      0.        4.          1
 5  100.      0.        20.         1
 6    1   1
 7  99.       .5        .075      .05
15    2                                                     Run 1
16  190.        1   1   0 90.       6.        90.       6.
23    7.5E-10
23    2.74
23    90.
23    6.                                                                        END
25    1.                                                                        END
16  190.        2   0   0 90.       0.        90.       0.
23    4.0E-09
23    1.                                                                        END
 3  1.          0   0   0   0                              Run 2
 3  1.          0   1   0   0
 4    3   0 180.
 5  150.      0.        4.          1
 5  100.      0.        20.         1                       Run 3
 5  100.      0.        480.        2
            11111111112222222222333333333344444444445555555555666666666677777777778
   12345678901234567890123456789012345678901234567890123456789012345678901234567890
```

Card Type **Column Number**

RUN 1 OF 3 RUNS DAAC-RETARD / NO RETARD / WITH DADT

LOAD INPUT DATA

STRESS FACTOR 1.000E 00
LIMIT STRESS 1.800E 02

STEP	MAX STRESS	MIN STRESS	UNITS(CYCLES)	MATERIAL TYPE
1	1.500E 02	0.0	4.000E 00	1
2	1.000E 02	0.0	2.000E 01	1

GEOMETRY INPUT DATA

CRACK TYPE	PTC = 1
WIDTH	9.900E 01
ADDITIONAL DIMENSION	0.0
RADIUS/NOTCH DEPTH	0.0
THICKNESS	5.000E-01
CRACK DEPTH	5.000E-02
HALF CRACK LENGTH	7.500E-02

MATERIAL INPUT DATA

MATERIAL TYPE	YIELD STRENGTH	GROWTH EQUATION	RETARDATION MODEL	CRITICAL STRESS INTENSITY (SURFACE)	THRESHOLD STRESS INTENSITY (SURFACE)	CRITICAL STRESS INTENSITY (DEPTH)	THRESHOLD STRESS INTENSITY (DEPTH)
1	1.900E 02	1	1	9.000E 01	6.000E 00	9.000E 01	6.000E 00
2	1.900E 02	2	0	9.000E 01	0.0	9.000E 01	0.0

--------------EQUATION CONSTANTS--------------

CONSTANT NUMBER	MATERIAL TYPE	CRACK GROWTH RATE SURFACE	CRACK GROWTH RATE DEPTH	RETARDATION MODEL SURFACE	RETARDATION MODEL DEPTH
1	1	7.500E-10	7.500E-10	1.000E 00	1.000E 00
2	1	2.740E 00	2.740E 00	0.0	0.0
3	1	9.000E 01	9.000E 01	0.0	0.0
4	1	6.000E 00	6.000E 00	0.0	0.0
1	2	4.000E-09	4.000E-09	0.0	0.0
2	2	1.000E 00	1.000E 00	0.0	0.0

ITERATION PARAMETERS

DESIGN LIFE	2.000E 02
CONVERGENCE EXPONENT	2.000E 00
ITERATION NUMBER	1
ITERATION TYPE	1

RUN 1 D6AC-RETARD / NO RETARD / WITH DADT

CRACK IS A PART THRU CRACK

BLOCK	STEP	CYCLES	HALF SURFACE CRACK LENGTH (IN)	CRACK DEPTH (IN)	KMAX-SURFACE (KSI ROOT-IN)	KMAX-DEPTH (KSI ROOT-IN)	SURFACE GROWTH RATE (IN/CYCLE)	DEPTH GROWTH RATE (IN/CYCLE)
1	1	0.0	7.500E-02	5.000E-02	4.346E 01	5.008E 01	2.659E-05	4.517E-05
1	1	4.000E 00	7.511E-02	5.018E-02	4.346E 01	5.008E 01	2.659E-05	4.517E-05
1	2	0.0	7.511E-02	5.018E-02	2.904E 01	3.341E 01	1.172E-06	1.783E-06
1	2	2.000E 01	7.513E-02	5.022E-02	2.904E 01	3.341E 01	1.172E-06	1.783E-06
2	1	0.0	7.513E-02	5.022E-02	4.358E 01	5.013E 01	2.684E-05	4.534E-05
2	1	4.000E 00	7.524E-02	5.040E-02	4.358E 01	5.013E 01	2.684E-05	4.534E-05
2	2	0.0	7.524E-02	5.040E-02	2.912E 01	3.344E 01	1.182E-06	1.788E-06
2	2	2.000E 01	7.526E-02	5.043E-02	2.912E 01	3.344E 01	1.182E-06	1.788E-06
4	1	0.0	7.539E-02	5.065E-02	4.381E 01	5.022E 01	2.734E-05	4.569E-05
4	1	4.000E 00	7.550E-02	5.083E-02	4.381E 01	5.022E 01	2.734E-05	4.569E-05
4	2	0.0	7.550E-02	5.083E-02	2.927E 01	3.351E 01	1.202E-06	1.798E-06
4	2	2.000E 01	7.553E-02	5.087E-02	2.927E 01	3.351E 01	1.202E-06	1.798E-06
6	1	0.0	7.566E-02	5.109E-02	4.405E 01	5.032E 01	2.786E-05	4.604E-05
6	1	4.000E 00	7.577E-02	5.127E-02	4.405E 01	5.032E 01	2.786E-05	4.604E-05
6	2	0.0	7.577E-02	5.127E-02	2.943E 01	3.357E 01	1.222E-06	1.809E-06
6	2	2.000E 01	7.580E-02	5.131E-02	2.943E 01	3.357E 01	1.222E-06	1.809E-06
8	1	0.0	7.593E-02	5.153E-02	4.428E 01	5.041E 01	2.839E-05	4.640E-05
8	1	4.000E 00	7.605E-02	5.172E-02	4.428E 01	5.041E 01	2.839E-05	4.640E-05
8	2	0.0	7.605E-02	5.172E-02	2.959E 01	3.364E 01	1.242E-06	1.819E-06
8	2	2.000E 01	7.607E-02	5.175E-02	2.959E 01	3.364E 01	1.242E-06	1.819E-06
10	1	0.0	7.621E-02	5.198E-02	4.452E 01	5.051E 01	2.893E-05	4.676E-05
10	1	4.000E 00	7.633E-02	5.216E-02	4.452E 01	5.051E 01	2.893E-05	4.676E-05
10	2	0.0	7.633E-02	5.216E-02	2.974E 01	3.370E 01	1.263E-06	1.830E-06
10	2	2.000E 01	7.635E-02	5.220E-02	2.974E 01	3.370E 01	1.263E-06	1.830E-06
12	1	0.0	7.649E-02	5.242E-02	4.475E 01	5.061E 01	2.947E-05	4.713E-05
12	1	4.000E 00	7.661E-02	5.261E-02	4.475E 01	5.061E 01	2.947E-05	4.713E-05
12	2	0.0	7.661E-02	5.261E-02	2.990E 01	3.376E 01	1.284E-06	1.841E-06
12	2	2.000E 01	7.664E-02	5.265E-02	2.990E 01	3.376E 01	1.284E-06	1.841E-06
14	1	0.0	7.678E-02	5.288E-02	4.499E 01	5.071E 01	3.004E-05	4.750E-05
14	1	4.000E 00	7.690E-02	5.307E-02	4.499E 01	5.071E 01	3.004E-05	4.750E-05
14	2	0.0	7.690E-02	5.307E-02	3.006E 01	3.383E 01	1.305E-06	1.852E-06
14	2	2.000E 01	7.693E-02	5.310E-02	3.006E 01	3.383E 01	1.305E-06	1.852E-06
16	1	0.0	7.708E-02	5.333E-02	4.522E 01	5.080E 01	3.061E-05	4.788E-05
16	1	4.000E 00	7.720E-02	5.352E-02	4.522E 01	5.080E 01	3.061E-05	4.788E-05
16	2	0.0	7.720E-02	5.352E-02	3.022E 01	3.390E 01	1.326E-06	1.863E-06
16	2	2.000E 01	7.723E-02	5.356E-02	3.022E 01	3.390E 01	1.326E-06	1.863E-06
18	1	0.0	7.738E-02	5.379E-02	4.546E 01	5.090E 01	3.119E-05	4.827E-05
18	1	4.000E 00	7.750E-02	5.398E-02	4.546E 01	5.090E 01	3.119E-05	4.827E-05
18	2	0.0	7.750E-02	5.398E-02	3.037E 01	3.396E 01	1.348E-06	1.874E-06
18	2	2.000E 01	7.753E-02	5.402E-02	3.037E 01	3.396E 01	1.348E-06	1.874E-06
20	1	0.0	7.768E-02	5.425E-02	4.570E 01	5.100E 01	3.179E-05	4.867E-05
20	1	4.000E 00	7.781E-02	5.445E-02	4.570E 01	5.100E 01	3.179E-05	4.867E-05
20	2	0.0	7.781E-02	5.445E-02	3.053E 01	3.403E 01	1.370E-06	1.885E-06
20	2	2.000E 01	7.784E-02	5.448E-02	3.053E 01	3.403E 01	1.370E-06	1.885E-06
22	1	0.0	7.799E-02	5.472E-02	4.594E 01	5.111E 01	3.240E-05	4.907E-05
22	1	4.000E 00	7.812E-02	5.491E-02	4.594E 01	5.111E 01	3.240E-05	4.907E-05
22	2	0.0	7.812E-02	5.491E-02	3.069E 01	3.410E 01	1.392E-06	1.896E-06
22	2	2.000E 01	7.815E-02	5.495E-02	3.069E 01	3.410E 01	1.392E-06	1.896E-06
24	1	0.0	7.831E-02	5.519E-02	4.618E 01	5.121E 01	3.303E-05	4.948E-05
24	1	4.000E 00	7.844E-02	5.538E-02	4.618E 01	5.121E 01	3.303E-05	4.948E-05
24	2	0.0	7.844E-02	5.538E-02	3.085E 01	3.417E 01	1.414E-06	1.908E-06
24	2	2.000E 01	7.847E-02	5.542E-02	3.085E 01	3.417E 01	1.414E-06	1.908E-06
26	1	0.0	7.863E-02	5.566E-02	4.642E 01	5.131E 01	3.367E-05	4.989E-05

180	2	2.000E 01	1.537E-01	1.308E-01	4.878E 01	4.789E 01	4.819E-06	4.573E-06
182	1	0.0	1.555E-01	1.323E-01	7.363E 01	7.229E 01	4.491E-04	3.766E-04
182	1	4.000E 00	1.573E-01	1.338E-01	7.399E 01	7.266E 01	4.721E-04	3.952E-04
182	2	0.0	1.573E-01	1.338E-01	4.936E 01	4.848E 01	5.125E-06	4.852E-06
182	2	2.000E 01	1.574E-01	1.339E-01	4.936E 01	4.848E 01	5.125E-06	4.852E-06
184	1	0.0	1.594E-01	1.356E-01	7.454E 01	7.322E 01	5.099E-04	4.252E-04
184	1	4.000E 00	1.615E-01	1.374E-01	7.491E 01	7.360E 01	5.377E-04	4.477E-04
184	2	0.0	1.615E-01	1.374E-01	5.001E 01	4.914E 01	5.515E-06	5.206E-06
184	2	2.000E 01	1.616E-01	1.375E-01	5.001E 01	4.914E 01	5.515E-06	5.206E-06
186	1	0.0	1.640E-01	1.394E-01	7.557E 01	7.428E 01	5.924E-04	4.912E-04
186	1	4.000E 00	1.664E-01	1.414E-01	7.594E 01	7.467E 01	6.270E-04	5.192E-04
186	2	0.0	1.664E-01	1.414E-01	5.074E 01	4.989E 01	6.038E-06	5.677E-06
186	2	2.000E 01	1.665E-01	1.415E-01	5.074E 01	4.989E 01	6.038E-06	5.677E-06
188	1	0.0	1.693E-01	1.438E-01	7.675E 01	7.551E 01	7.116E-04	5.867E-04
188	1	4.000E 00	1.722E-01	1.462E-01	7.713E 01	7.591E 01	7.571E-04	6.235E-04
188	2	0.0	1.722E-01	1.462E-01	5.159E 01	5.078E 01	6.802E-06	6.353E-06
188	2	2.000E 01	1.723E-01	1.464E-01	5.159E 01	5.078E 01	6.802E-06	6.353E-06
190	1	0.0	1.757E-01	1.492E-01	7.816E 01	7.699E 01	9.025E-04	7.399E-04
190	1	4.000E 00	1.795E-01	1.522E-01	7.893E 01	7.782E 01	1.040E-03	8.509E-04
190	2	0.0	1.795E-01	1.522E-01	5.263E 01	5.189E 01	5.933E-06	5.695E-06
190	2	2.000E 01	1.796E-01	1.524E-01	5.263E 01	5.189E 01	5.933E-06	5.695E-06
192	1	0.0	1.842E-01	1.561E-01	7.993E 01	7.889E 01	1.266E-03	1.032E-03
192	1	4.000E 00	1.896E-01	1.606E-01	8.073E 01	7.975E 01	1.498E-03	1.220E-03
192	2	0.0	1.896E-01	1.606E-01	5.404E 01	5.341E 01	8.160E-06	7.631E-06
192	2	2.000E 01	1.898E-01	1.607E-01	5.404E 01	5.341E 01	8.160E-06	7.631E-06
194	1	0.0	1.973E-01	1.669E-01	8.262E 01	8.181E 01	2.379E-03	1.925E-03
194	1	4.000E 00	2.100E-01	1.772E-01	8.509E 01	8.454E 01	5.316E-03	4.317E-03
194	2	0.0	2.100E-01	1.772E-01	5.673E 01	5.637E 01	7.239E-06	7.104E-06
194	2	2.000E 01	2.107E-01	1.773E-01	5.673E 01	5.637E 01	7.239E-06	7.104E-06

LIMIT LOAD FRACTURE OCCURS IN THE 184 BLOCK 1 STEP AFTER 3.190E 00 CYCLES

CRITICAL K AT DEPTH HAS BEEN EXCEEDED IN THE 195 BLOCK AND THE 1 STEP AFTER 1.835E 00 CYCLES

ITERATION RESULTS

THICKNESS	A	C	LIFE	PERCENT OF REQUIRED LIFE
5.000E-01	5.000E-02	7.500E-02	1.942E 02	97.11
5.074E-01	5.000E-02	7.500E-02	2.103E 02	105.15
4.948E-01	5.000E-02	7.500E-02	1.832E 02	91.62

RUN 2 OF 3 RUNS D6AC-RETARD / NO RETARD / WITH DADT

LOAD INPUT DATA

STRESS FACTOR 1.000E 00
LIMIT STRESS 1.800E 02

STEP	MAX STRESS	MIN STRESS	UNITS(CYCLES)	MATERIAL TYPE
1	1.500E 02	0.0	4.000E 00	1
2	1.000E 02	0.0	2.000E 01	1

GEOMETRY INPUT DATA

CRACK TYPE	PTC = 1
WIDTH	9.900E 01
ADDITIONAL DIMENSION	0.0
RADIUS/NOTCH DEPTH	0.0
THICKNESS	5.000E-01
CRACK DEPTH	5.000E-02
HALF CRACK LENGTH	7.500E-02

B-16

MATERIAL INPUT DATA

MATERIAL TYPE	YIELD STRENGTH	GROWTH EQUATION	RETARDATION MODEL	CRITICAL STRESS INTENSITY (SURFACE)	THRESHOLD STRESS INTENSITY (SURFACE)	CRITICAL STRESS INTENSITY (DEPTH)	THRESHOLD STRESS INTENSITY (DEPTH)
1	1.900E 02	1	0	9.000E 01	6.000E 00	9.000E 01	6.000E 00
2	1.900E 02	2	0	9.000E 01	0.0	9.000E 01	0.0

		EQUATION CONSTANTS			
CONSTANT NUMBER	MATERIAL TYPE	CRACK GROWTH RATE SURFACE	CRACK GROWTH RATE DEPTH	RETARDATION MODEL SURFACE	RETARDATION MODEL DEPTH
1	1	7.500E-10	7.500E-10	1.000E 00	1.000E 00
2	1	2.740E 00	2.740E 00	0.0	0.0
3	1	9.000E 01	9.000E 01	0.0	0.0
4	1	6.000E 00	6.000E 00	0.0	0.0
1	2	4.000E-09	4.000E-09	0.0	0.0
2	2	1.000E 00	1.000E 00	0.0	0.0

ORIGINAL PAGE IS POOR QUALITY

RUN 2 D6AC-RETARD / NO RETARD / WITH DADT

CRACK IS A PART THRU CRACK

BLOCK	STEP	CYCLES	HALF SURFACE CRACK LENGTH (IN)	CRACK DEPTH (IN)	KMAX-SURFACE (KSI ROOT-IN)	KMAX-DEPTH (KSI ROOT-IN)	SURFACE GROWTH RATE (IN/CYCLE)	DEPTH GROWTH RATE (IN/CYCLE)
1	1	0.0	7.500E-02	5.000E-02	4.346E 01	5.008E 01	2.659E-05	4.517E-05
1	1	4.000E 00	7.511E-02	5.018E-02	4.346E 01	5.008E 01	2.659E-05	4.517E-05
1	2	0.0	7.511E-02	5.018E-02	2.904E 01	3.341E 01	7.694E-06	1.152E-05
1	2	2.000E 01	7.526E-02	5.041E-02	2.904E 01	3.341E 01	7.694E-06	1.152E-05
2	1	0.0	7.526E-02	5.041E-02	4.368E 01	5.017E 01	2.706E-05	4.551E-05
2	1	4.000E 00	7.537E-02	5.059E-02	4.368E 01	5.017E 01	2.706E-05	4.551E-05
2	2	0.0	7.537E-02	5.059E-02	2.919E 01	3.348E 01	7.804E-06	1.158E-05
2	2	2.000E 01	7.552E-02	5.082E-02	2.919E 01	3.348E 01	7.804E-06	1.158E-05
4	1	0.0	7.579E-02	5.124E-02	4.412E 01	5.036E 01	2.803E-05	4.621E-05
4	1	4.000E 00	7.590E-02	5.143E-02	4.412E 01	5.036E 01	2.803E-05	4.621E-05
4	2	0.0	7.590E-02	5.143E-02	2.948E 01	3.360E 01	8.027E-06	1.171E-05
4	2	2.000E 01	7.607E-02	5.166E-02	2.948E 01	3.360E 01	8.027E-06	1.171E-05
6	1	0.0	7.634E-02	5.208E-02	4.456E 01	5.055E 01	2.904E-05	4.693E-05
6	1	4.000E 00	7.646E-02	5.227E-02	4.456E 01	5.055E 01	2.904E-05	4.693E-05
6	2	0.0	7.646E-02	5.227E-02	2.977E 01	3.373E 01	8.256E-06	1.184E-05
6	2	2.000E 01	7.662E-02	5.251E-02	2.977E 01	3.373E 01	8.256E-06	1.184E-05
8	1	0.0	7.691E-02	5.293E-02	4.501E 01	5.075E 01	3.008E-05	4.766E-05
8	1	4.000E 00	7.703E-02	5.312E-02	4.501E 01	5.075E 01	3.008E-05	4.766E-05
8	2	0.0	7.703E-02	5.312E-02	3.007E 01	3.386E 01	8.491E-06	1.198E-05
8	2	2.000E 01	7.720E-02	5.336E-02	3.007E 01	3.386E 01	8.491E-06	1.198E-05
10	1	0.0	7.749E-02	5.380E-02	4.545E 01	5.094E 01	3.117E-05	4.842E-05
10	1	4.000E 00	7.762E-02	5.399E-02	4.545E 01	5.094E 01	3.117E-05	4.842E-05
10	2	0.0	7.762E-02	5.399E-02	3.037E 01	3.399E 01	8.732E-06	1.212E-05
10	2	2.000E 01	7.779E-02	5.423E-02	3.037E 01	3.399E 01	8.732E-06	1.212E-05
12	1	0.0	7.810E-02	5.467E-02	4.590E 01	5.114E 01	3.230E-05	4.921E-05
12	1	4.000E 00	7.823E-02	5.487E-02	4.590E 01	5.114E 01	3.230E-05	4.921E-05
12	2	0.0	7.823E-02	5.487E-02	3.067E 01	3.412E 01	8.979E-06	1.226E-05
12	2	2.000E 01	7.841E-02	5.511E-02	3.067E 01	3.412E 01	8.979E-06	1.226E-05
14	1	0.0	7.872E-02	5.556E-02	4.635E 01	5.134E 01	3.348E-05	5.002E-05
14	1	4.000E 00	7.885E-02	5.576E-02	4.635E 01	5.134E 01	3.348E-05	5.002E-05
14	2	0.0	7.885E-02	5.576E-02	3.097E 01	3.426E 01	9.232E-06	1.240E-05
14	2	2.000E 01	7.904E-02	5.601E-02	3.097E 01	3.426E 01	9.232E-06	1.240E-05
16	1	0.0	7.936E-02	5.646E-02	4.680E 01	5.155E 01	3.471E-05	5.086E-05
16	1	4.000E 00	7.950E-02	5.666E-02	4.680E 01	5.155E 01	3.471E-05	5.086E-05
16	2	0.0	7.950E-02	5.666E-02	3.127E 01	3.439E 01	9.492E-06	1.255E-05
16	2	2.000E 01	7.969E-02	5.691E-02	3.127E 01	3.439E 01	9.492E-06	1.255E-05
18	1	0.0	8.002E-02	5.737E-02	4.725E 01	5.176E 01	3.598E-05	5.175E-05
18	1	4.000E 00	8.017E-02	5.758E-02	4.725E 01	5.176E 01	3.598E-05	5.175E-05
18	2	0.0	8.017E-02	5.758E-02	3.157E 01	3.454E 01	9.757E-06	1.272E-05
18	2	2.000E 01	8.036E-02	5.783E-02	3.157E 01	3.454E 01	9.757E-06	1.272E-05
20	1	0.0	8.071E-02	5.830E-02	4.769E 01	5.202E 01	3.728E-05	5.287E-05
20	1	4.000E 00	8.086E-02	5.851E-02	4.769E 01	5.202E 01	3.728E-05	5.287E-05
20	2	0.0	8.086E-02	5.851E-02	3.186E 01	3.472E 01	1.002E-05	1.291E-05
20	2	2.000E 01	8.106E-02	5.877E-02	3.186E 01	3.472E 01	1.002E-05	1.291E-05
22	1	0.0	8.141E-02	5.924E-02	4.814E 01	5.229E 01	3.864E-05	5.403E-05
22	1	4.000E 00	8.157E-02	5.946E-02	4.814E 01	5.229E 01	3.864E-05	5.403E-05
22	2	0.0	8.157E-02	5.946E-02	3.216E 01	3.490E 01	1.030E-05	1.311E-05
22	2	2.000E 01	8.177E-02	5.972E-02	3.216E 01	3.490E 01	1.030E-05	1.311E-05
24	1	0.0	8.214E-02	6.020E-02	4.859E 01	5.256E 01	4.007E-05	5.524E-05
24	1	4.000E 00	8.230E-02	6.042E-02	4.859E 01	5.256E 01	4.007E-05	5.524E-05
24	2	0.0	8.230E-02	6.042E-02	3.246E 01	3.508E 01	1.058E-05	1.332E-05
24	2	2.000E 01	8.251E-02	6.069E-02	3.246E 01	3.508E 01	1.058E-05	1.332E-05
26	1	0.0	8.289E-02	6.118E-02	4.905E 01	5.284E 01	4.196E-05	5.690E-05

88	1	4.000E 00	1.268E-01	1.073E-01	6.604E 01	6.502E 01	1.854E-04	1.672E-04
88	2	0.0	1.268E-01	1.073E-01	4.417E 01	4.347E 01	2.814E-05	2.661E-05
88	2	2.000E 01	1.274E-01	1.078E-01	4.417E 01	4.347E 01	2.814E-05	2.661E-05
90	1	0.0	1.287E-01	1.091E-01	6.681E 01	6.569E 01	2.007E-04	1.789E-04
90	1	4.000E 00	1.295E-01	1.098E-01	6.681E 01	6.569E 01	2.007E-04	1.789E-04
90	2	0.0	1.295E-01	1.098E-01	4.469E 01	4.393E 01	2.932E-05	2.761E-05
90	2	2.000E 01	1.301E-01	1.103E-01	4.469E 01	4.393E 01	2.932E-05	2.761E-05
92	1	0.0	1.315E-01	1.116E-01	6.761E 01	6.641E 01	2.184E-04	1.925E-04
92	1	4.000E 00	1.324E-01	1.124E-01	6.761E 01	6.641E 01	2.184E-04	1.925E-04
92	2	0.0	1.324E-01	1.124E-01	4.523E 01	4.442E 01	3.062E-05	2.870E-05
92	2	2.000E 01	1.330E-01	1.130E-01	4.523E 01	4.442E 01	3.062E-05	2.870E-05
94	1	0.0	1.346E-01	1.144E-01	6.844E 01	6.717E 01	2.391E-04	2.084E-04
94	1	4.000E 00	1.355E-01	1.152E-01	6.844E 01	6.717E 01	2.391E-04	2.084E-04
94	2	0.0	1.355E-01	1.152E-01	4.579E 01	4.494E 01	3.204E-05	2.992E-05
94	2	2.000E 01	1.362E-01	1.158E-01	4.579E 01	4.494E 01	3.204E-05	2.992E-05
96	1	0.0	1.378E-01	1.173E-01	6.932E 01	6.798E 01	2.637E-04	2.273E-04
96	1	4.000E 00	1.389E-01	1.182E-01	6.932E 01	6.798E 01	2.637E-04	2.273E-04
96	2	0.0	1.389E-01	1.182E-01	4.639E 01	4.549E 01	3.360E-05	3.128E-05
96	2	2.000E 01	1.396E-01	1.188E-01	4.639E 01	4.549E 01	3.360E-05	3.128E-05
98	1	0.0	1.414E-01	1.204E-01	7.025E 01	6.885E 01	2.935E-04	2.501E-04
98	1	4.000E 00	1.425E-01	1.214E-01	7.025E 01	6.885E 01	2.935E-04	2.501E-04
98	2	0.0	1.425E-01	1.214E-01	4.702E 01	4.609E 01	3.535E-05	3.281E-05
98	2	2.000E 01	1.432E-01	1.221E-01	4.702E 01	4.609E 01	3.535E-05	3.281E-05
100	1	0.0	1.452E-01	1.238E-01	7.123E 01	6.979E 01	3.303E-04	2.783E-04
100	1	4.000E 00	1.465E-01	1.249E-01	7.123E 01	6.979E 01	3.303E-04	2.783E-04
100	2	0.0	1.465E-01	1.249E-01	4.770E 01	4.674E 01	3.731E-05	3.455E-05
100	2	2.000E 01	1.473E-01	1.256E-01	4.770E 01	4.674E 01	3.731E-05	3.455E-05
102	1	0.0	1.494E-01	1.275E-01	7.229E 01	7.081E 01	3.770E-04	3.139E-04
102	1	4.000E 00	1.510E-01	1.287E-01	7.229E 01	7.081E 01	3.770E-04	3.139E-04
102	2	0.0	1.510E-01	1.287E-01	4.843E 01	4.745E 01	3.956E-05	3.658E-05
102	2	2.000E 01	1.517E-01	1.295E-01	4.843E 01	4.745E 01	3.956E-05	3.658E-05
104	1	0.0	1.542E-01	1.316E-01	7.345E 01	7.195E 01	4.383E-04	3.608E-04
104	1	4.000E 00	1.560E-01	1.330E-01	7.381E 01	7.233E 01	4.604E-04	3.788E-04
104	2	0.0	1.560E-01	1.330E-01	4.923E 01	4.825E 01	4.218E-05	3.898E-05
104	2	2.000E 01	1.568E-01	1.338E-01	4.923E 01	4.825E 01	4.218E-05	3.898E-05
106	1	0.0	1.596E-01	1.362E-01	7.472E 01	7.323E 01	5.232E-04	4.256E-04
106	1	4.000E 00	1.617E-01	1.379E-01	7.509E 01	7.362E 01	5.518E-04	4.488E-04
106	2	0.0	1.617E-01	1.379E-01	5.012E 01	4.915E 01	4.533E-05	4.191E-05
106	2	2.000E 01	1.626E-01	1.387E-01	5.012E 01	4.915E 01	4.533E-05	4.191E-05
108	1	0.0	1.659E-01	1.415E-01	7.617E 01	7.470E 01	6.490E-04	5.216E-04
108	1	4.000E 00	1.686E-01	1.436E-01	7.654E 01	7.511E 01	6.883E-04	5.536E-04
108	2	0.0	1.686E-01	1.436E-01	5.115E 01	5.021E 01	4.926E-05	4.565E-05
108	2	2.000E 01	1.695E-01	1.445E-01	5.115E 01	5.021E 01	4.926E-05	4.565E-05
110	1	0.0	1.736E-01	1.479E-01	7.787E 01	7.647E 01	8.579E-04	6.810E-04
110	1	4.000E 00	1.771E-01	1.507E-01	7.825E 01	7.690E 01	9.174E-04	7.295E-04
110	2	0.0	1.771E-01	1.507E-01	5.239E 01	5.152E 01	5.449E-05	5.077E-05
110	2	2.000E 01	1.782E-01	1.518E-01	5.239E 01	5.152E 01	5.449E-05	5.077E-05
112	1	0.0	1.837E-01	1.562E-01	8.000E 01	7.876E 01	1.284E-03	1.007E-03
112	1	4.000E 00	1.892E-01	1.606E-01	8.079E 01	7.966E 01	1.518E-03	1.197E-03
112	2	0.0	1.892E-01	1.606E-01	5.406E 01	5.333E 01	6.249E-05	5.887E-05
112	2	2.000E 01	1.905E-01	1.618E-01	5.406E 01	5.333E 01	6.249E-05	5.887E-05
114	1	0.0	1.998E-01	1.693E-01	8.325E 01	8.233E 01	2.837E-03	2.197E-03
114	1	4.000E 00	2.175E-01	1.833E-01	8.614E 01	8.568E 01	8.464E-03	6.796E-03
114	2	0.0	2.175E-01	1.833E-01	5.769E 01	5.742E 01	8.501E-05	8.302E-05
114	2	2.000E 01	2.192E-01	1.849E-01	5.769E 01	5.742E 01	8.501E-05	8.302E-05

LIMIT LOAD FRACTURE OCCURS IN THE 106 BLOCK 1 STEP AFTER 3.200E 00 CYCLES

CRITICAL K AT DEPTH HAS BEEN EXCEEDED IN THE 115 BLOCK AND THE 1 STEP AFTER 5.410E-01 CYCLES

RUN 3 OF 3 RUNS D6AC-RETARD / NO RETARD / WITH DADT

ORIGINAL PAGE IS OF POOR QUALITY

LOAD INPUT DATA

STRESS FACTOR 1.000E 00
LIMIT STRESS 1.800E 02

STEP	MAX STRESS	MIN STRESS	UNITS(CYCLES)	MATERIAL TYPE
1	1.500E 02	0.0	4.000E 00	1
2	1.000E 02	0.0	2.000E 01	1
3	1.000E 02	0.0	4.300E 02	2

GEOMETRY INPUT DATA

CRACK TYPE	PTC - 1
WIDTH	9.900E 01
ADDITIONAL DIMENSION	0.0
RADIUS/NOTCH DEPTH	0.0
THICKNESS	5.000E-01
CRACK DEPTH	5.000E-02
HALF CRACK LENGTH	7.500E-02

MATERIAL INPUT DATA

MATERIAL TYPE	YIELD STRENGTH	GROWTH EQUATION	RETARDATION MODEL	CRITICAL STRESS INTENSITY (SURFACE)	THRESHOLD STRESS INTENSITY (SURFACE)	CRITICAL STRESS INTENSITY (DEPTH)	THRESHOLD STRESS INTENSITY (DEPTH)
1	1.900E 02	1	0	9.000E 01	6.000E 00	9.000E 01	6.000E 00
2	1.900E 02	2	0	9.000E 01	0.0	9.000E 01	0.0

--------------EQUATION CONSTANTS--------------

CONSTANT NUMBER	MATERIAL TYPE	CRACK GROWTH RATE SURFACE	CRACK GROWTH RATE DEPTH	RETARDATION MODEL SURFACE	RETARDATION MODEL DEPTH
1	1	7.500E-10	7.500E-10	1.000E 00	1.000E 00
2	1	2.740E 00	2.740E 00	0.0	0.0
3	1	9.000E 01	9.000E 01	0.0	0.0
4	1	6.000E 00	6.000E 00	0.0	0.0
1	2	4.000E-09	4.000E-09	0.0	0.0
2	2	1.000E 00	1.000E 00	0.0	0.0

RUN 3 D6AC-RETARD / NO RETARD / WITH DADT

CRACK IS A PART THRU CRACK

BLOCK	STEP	CYCLES	HALF SURFACE CRACK LENGTH (IN)	CRACK DEPTH (IN)	KMAX-SURFACE (KSI ROOT-IN)	KMAX-DEPTH (KSI ROOT-IN)	SURFACE GROWTH RATE (IN/CYCLE)	DEPTH GROWTH RATE (IN/CYCLE)
1	1	0.0	7.500E-02	5.000E-02	4.346E 01	5.008E 01	2.659E-05	4.517E-05
1	1	4.000E 00	7.511E-02	5.018E-02	4.346E 01	5.008E 01	2.659E-05	4.517E-05
1	2	0.0	7.511E-02	5.018E-02	2.904E 01	3.341E 01	7.694E-06	1.152E-05
1	2	2.000E 01	7.526E-02	5.041E-02	2.904E 01	3.341E 01	7.694E-06	1.152E-05
1	3	0.0	7.526E-02	5.041E-02	2.912E 01	3.345E 01	1.165E-07	1.338E-07
1	3	4.800E 02	7.532E-02	5.048E-02	2.912E 01	3.345E 01	1.165E-07	1.338E-07
2	1	0.0	7.532E-02	5.048E-02	4.372E 01	5.019E 01	2.713E-05	4.558E-05
2	1	4.000E 00	7.542E-02	5.066E-02	4.372E 01	5.019E 01	2.713E-05	4.558E-05
2	2	0.0	7.542E-02	5.066E-02	2.921E 01	3.349E 01	7.820E-06	1.160E-05
2	2	2.000E 01	7.558E-02	5.089E-02	2.921E 01	3.349E 01	7.820E-06	1.160E-05
2	3	0.0	7.558E-02	5.089E-02	2.929E 01	3.353E 01	1.172E-07	1.341E-07
2	3	4.800E 02	7.564E-02	5.095E-02	2.929E 01	3.353E 01	1.172E-07	1.341E-07
4	1	0.0	7.596E-02	5.144E-02	4.422E 01	5.042E 01	2.825E-05	4.643E-05
4	1	4.000E 00	7.608E-02	5.162E-02	4.422E 01	5.042E 01	2.825E-05	4.643E-05
4	2	0.0	7.608E-02	5.162E-02	2.955E 01	3.364E 01	8.077E-06	1.175E-05
4	2	2.000E 01	7.624E-02	5.186E-02	2.955E 01	3.364E 01	8.077E-06	1.175E-05
4	3	0.0	7.624E-02	5.186E-02	2.963E 01	3.368E 01	1.185E-07	1.347E-07
4	3	4.800E 02	7.629E-02	5.192E-02	2.963E 01	3.368E 01	1.185E-07	1.347E-07
6	1	0.0	7.663E-02	5.241E-02	4.473E 01	5.065E 01	2.942E-05	4.730E-05
6	1	4.000E 00	7.675E-02	5.260E-02	4.473E 01	5.065E 01	2.942E-05	4.730E-05
6	2	0.0	7.675E-02	5.260E-02	2.988E 01	3.379E 01	8.342E-06	1.191E-05
6	2	2.000E 01	7.692E-02	5.284E-02	2.988E 01	3.379E 01	8.342E-06	1.191E-05
6	3	0.0	7.692E-02	5.284E-02	2.997E 01	3.383E 01	1.199E-07	1.353E-07
6	3	4.800E 02	7.697E-02	5.290E-02	2.997E 01	3.383E 01	1.199E-07	1.353E-07
8	1	0.0	7.732E-02	5.340E-02	4.523E 01	5.088E 01	3.064E-05	4.820E-05
8	1	4.000E 00	7.744E-02	5.359E-02	4.523E 01	5.088E 01	3.064E-05	4.820E-05
8	2	0.0	7.744E-02	5.359E-02	3.022E 01	3.395E 01	8.614E-06	1.208E-05
8	2	2.000E 01	7.762E-02	5.383E-02	3.022E 01	3.395E 01	8.614E-06	1.208E-05
8	3	0.0	7.762E-02	5.383E-02	3.031E 01	3.399E 01	1.212E-07	1.360E-07
8	3	4.800E 02	7.767E-02	5.390E-02	3.031E 01	3.399E 01	1.212E-07	1.360E-07
10	1	0.0	7.803E-02	5.440E-02	4.575E 01	5.112E 01	3.191E-05	4.913E-05
10	1	4.000E 00	7.816E-02	5.460E-02	4.575E 01	5.112E 01	3.191E-05	4.913E-05
10	2	0.0	7.816E-02	5.460E-02	3.056E 01	3.411E 01	8.894E-06	1.224E-05
10	2	2.000E 01	7.834E-02	5.484E-02	3.056E 01	3.411E 01	8.894E-06	1.224E-05
10	3	0.0	7.834E-02	5.484E-02	3.065E 01	3.415E 01	1.226E-07	1.366E-07
10	3	4.800E 02	7.840E-02	5.491E-02	3.065E 01	3.415E 01	1.226E-07	1.366E-07
12	1	0.0	7.877E-02	5.542E-02	4.626E 01	5.136E 01	3.325E-05	5.009E-05
12	1	4.000E 00	7.890E-02	5.562E-02	4.626E 01	5.136E 01	3.325E-05	5.009E-05
12	2	0.0	7.890E-02	5.562E-02	3.091E 01	3.427E 01	9.182E-06	1.242E-05
12	2	2.000E 01	7.908E-02	5.587E-02	3.091E 01	3.427E 01	9.182E-06	1.242E-05
12	3	0.0	7.908E-02	5.587E-02	3.099E 01	3.431E 01	1.240E-07	1.372E-07
12	3	4.800E 02	7.914E-02	5.593E-02	3.099E 01	3.431E 01	1.240E-07	1.372E-07
14	1	0.0	7.952E-02	5.645E-02	4.677E 01	5.160E 01	3.464E-05	5.109E-05
14	1	4.000E 00	7.966E-02	5.666E-02	4.677E 01	5.160E 01	3.464E-05	5.109E-05
14	2	0.0	7.966E-02	5.666E-02	3.125E 01	3.443E 01	9.479E-06	1.259E-05
14	2	2.000E 01	7.985E-02	5.691E-02	3.125E 01	3.443E 01	9.479E-06	1.259E-05
14	3	0.0	7.985E-02	5.691E-02	3.133E 01	3.447E 01	1.253E-07	1.379E-07
14	3	4.800E 02	7.991E-02	5.697E-02	3.133E 01	3.447E 01	1.253E-07	1.379E-07
16	1	0.0	8.031E-02	5.750E-02	4.729E 01	5.185E 01	3.610E-05	5.212E-05
16	1	4.000E 00	8.045E-02	5.771E-02	4.729E 01	5.185E 01	3.610E-05	5.212E-05
16	2	0.0	8.045E-02	5.771E-02	3.159E 01	3.460E 01	9.783E-06	1.278E-05
16	2	2.000E 01	8.065E-02	5.796E-02	3.159E 01	3.460E 01	9.783E-06	1.278E-05
16	3	0.0	8.065E-02	5.796E-02	3.168E 01	3.465E 01	1.267E-07	1.386E-07

100	1	4.000E 00	1.798E-01	1.530E-01	7.916E 01	7.788E 01	1.087E-03	8.596E-04
100	2	0.0	1.798E-01	1.530E-01	5.279E 01	5.193E 01	5.628E-05	5.248E-05
100	2	2.000E 01	1.810E-01	1.541E-01	5.279E 01	5.193E 01	5.628E-05	5.248E-05
100	3	0.0	1.810E-01	1.541E-01	5.297E 01	5.210E 01	2.119E-07	2.084E-07
100	3	4.800E 02	1.811E-01	1.542E-01	5.297E 01	5.210E 01	2.119E-07	2.084E-07
102	1	0.0	1.873E-01	1.593E-01	8.077E 01	7.956E 01	1.512E-03	1.174E-03
102	1	4.000E 00	1.940E-01	1.645E-01	8.196E 01	8.094E 01	1.998E-03	1.572E-03
102	2	0.0	1.940E-01	1.645E-01	5.470E 01	5.404E 01	6.593E-05	6.238E-05
102	2	2.000E 01	1.953E-01	1.657E-01	5.470E 01	5.404E 01	6.593E-05	6.238E-05
102	3	0.0	1.953E-01	1.657E-01	5.491E 01	5.422E 01	2.197E-07	2.169E-07
102	3	4.800E 02	1.954E-01	1.658E-01	5.491E 01	5.422E 01	2.197E-07	2.169E-07
104	1	0.0	2.083E-01	1.762E-01	8.490E 01	8.416E 01	4.928E-03	3.781E-03

LIMIT LOAD FRACTURE OCCURS IN THE 95 BLOCK 2 STEP AFTER 0.0 CYCLES

CRITICAL K AT DEPTH HAS BEEN EXCEEDED IN THE 104 BLOCK AND THE 1 STEP AFTER 2.179E 00 CYCLES

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             11111111112222222222333333333344444444445555555555666666666677777777778
    12345678901234567890123456789012345678901234567890123456789012345678901234567890

 1  D6AC  ITERATION ON CRACK SIZE / PROOF TEST
 2     2  1000  10   1
 3   1.          0   1   1   1   4  10 4.        200.
 4     1   0 180.
 5   120.      0.        25.         1
 6     1   1
 7   99.       .5        .075      .05
15     1                                                                                Run 1
16   190.        1   0   0 90.       6.        90.       6.
23     7.5E-10
23     2.74
23     90.
23     6.                                                                        END
 3   1.          0   0   0   0                               1
27   .333      70.       60.       0.        .5        180.                             Run 2

             11111111112222222222333333333344444444445555555555666666666677777777778
    12345678901234567890123456789012345678901234567890123456789012345678901234567890
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Card Type Column Number

RUN 1 OF 2 RUNS D6AC ITERATION ON CRACK SIZE / PROOF TEST

LOAD INPUT DATA

STRESS FACTOR 1.000E 00
LIMIT STRESS 1.800E 02

STEP	MAX STRESS	MIN STRESS	UNITS(CYCLES)	MATERIAL TYPE
1	1.200E 02	0.0	2.500E 01	1

GEOMETRY INPUT DATA

CRACK TYPE PTC - 1
WIDTH 9.900E 01
ADDITIONAL DIMENSION 0.0
RADIUS/NOTCH DEPTH 0.0
THICKNESS 5.000E-01
CRACK DEPTH 5.000E-02
HALF CRACK LENGTH 7.500E-02

MATERIAL INPUT DATA

MATERIAL TYPE	YIELD STRENGTH	GROWTH EQUATION	RETARDATION MODEL	CRITICAL STRESS INTENSITY (SURFACE)	THRESHOLD STRESS INTENSITY (SURFACE)	CRITICAL STRESS INTENSITY (DEPTH)	THRESHOLD STRESS INTENSITY (DEPTH)
1	1.900E 02	1	0	9.000E 01	6.000E 00	9.000E 01	6.000E 00

==============EQUATION CONSTANTS=============

CONSTANT NUMBER	MATERIAL TYPE	CRACK GROWTH RATE SURFACE	CRACK GROWTH RATE DEPTH	RETARDATION MODEL SURFACE	RETARDATION MODEL DEPTH
1	1	7.500E-10	7.500E-10	0.0	0.0
2	1	2.740E 00	2.740E 00	0.0	0.0
3	1	9.000E 01	9.000E 01	0.0	0.0
4	1	6.000E 00	6.000E 00	0.0	0.0

ITERATION PARAMETERS

DESIGN LIFE 2.000E 02
CONVERGENCE EXPONENT 4.000E 00
ITERATION NUMBER 1
ITERATION TYPE 4

RUN 1 D6AC ITERATION ON CRACK SIZE / PROOF TEST

CRACK IS A PART THRU CRACK

BLOCK	STEP	CYCLES	HALF SURFACE CRACK LENGTH (IN)	CRACK DEPTH (IN)	KMAX-SURFACE (KSI ROOT-IN)	KMAX-DEPTH (KSI ROOT-IN)	SURFACE GROWTH RATE (IN/CYCLE)	DEPTH GROWTH RATE (IN/CYCLE)
1	1	0.0	7.500E-02	5.000E-02	3.477E 01	4.007E 01	1.297E-05	2.020E-05
1	1	2.500E 01	7.532E-02	5.051E-02	3.498E 01	4.016E 01	1.321E-05	2.036E-05
10	1	0.0	7.815E-02	5.469E-02	3.672E 01	4.093E 01	1.532E-05	2.167E-05
10	1	2.500E 01	7.853E-02	5.523E-02	3.672E 01	4.093E 01	1.532E-05	2.167E-05
20	1	0.0	8.231E-02	6.033E-02	3.891E 01	4.209E 01	1.838E-05	2.381E-05
20	1	2.500E 01	8.277E-02	6.092E-02	3.891E 01	4.209E 01	1.838E-05	2.381E-05
30	1	0.0	8.731E-02	6.659E-02	4.118E 01	4.351E 01	2.212E-05	2.668E-05
30	1	2.500E 01	8.786E-02	6.725E-02	4.141E 01	4.366E 01	2.255E-05	2.700E-05
40	1	0.0	9.334E-02	7.362E-02	4.351E 01	4.497E 01	2.669E-05	3.001E-05
40	1	2.500E 01	9.401E-02	7.437E-02	4.375E 01	4.513E 01	2.720E-05	3.037E-05
50	1	0.0	1.006E-01	8.158E-02	4.596E 01	4.662E 01	3.246E-05	3.423E-05
50	1	2.500E 01	1.014E-01	8.243E-02	4.620E 01	4.679E 01	3.310E-05	3.470E-05
60	1	0.0	1.096E-01	9.075E-02	4.861E 01	4.857E 01	4.012E-05	4.000E-05
60	1	2.500E 01	1.106E-01	9.175E-02	4.886E 01	4.876E 01	4.095E-05	4.063E-05
70	1	0.0	1.208E-01	1.016E-01	5.155E 01	5.092E 01	5.088E-05	4.836E-05
70	1	2.500E 01	1.220E-01	1.029E-01	5.182E 01	5.115E 01	5.198E-05	4.923E-05
80	1	0.0	1.352E-01	1.151E-01	5.494E 01	5.386E 01	6.729E-05	6.146E-05
80	1	2.500E 01	1.369E-01	1.167E-01	5.522E 01	5.411E 01	6.888E-05	6.275E-05
90	1	0.0	1.551E-01	1.329E-01	5.910E 01	5.770E 01	9.609E-05	8.505E-05
90	1	2.500E 01	1.575E-01	1.351E-01	5.939E 01	5.798E 01	9.865E-05	8.717E-05
100	1	0.0	1.856E-01	1.596E-01	6.479E 01	6.330E 01	1.633E-04	1.413E-04
100	1	2.500E 01	1.898E-01	1.632E-01	6.544E 01	6.395E 01	1.743E-04	1.505E-04
110	1	0.0	2.581E-01	2.221E-01	7.641E 01	7.549E 01	6.746E-04	5.850E-04
110	1	2.500E 01	2.791E-01	2.404E-01	7.913E 01	7.844E 01	1.080E-03	9.498E-04

LIMIT LOAD FRACTURE OCCURS IN THE 91 BLOCK 1 STEP AFTER 1.526E 01 CYCLES

CRITICAL K AT DEPTH HAS BEEN EXCEEDED IN THE 111 BLOCK AND THE 1 STEP AFTER 2.168E 01 CYCLES

RUN 1 D6AC ITERATION ON CRACK SIZE / PROOF TEST

CRACK IS A PART THRU CRACK

BLOCK	STEP	CYCLES	HALF SURFACE CRACK LENGTH (IN)	CRACK DEPTH (IN)	KMAX-SURFACE (KSI ROOT-IN)	KMAX-DEPTH (KSI ROOT-IN)	SURFACE GROWTH RATE (IN/CYCLE)	DEPTH GROWTH RATE (IN/CYCLE)
1	1	0.0	4.158E-02	2.772E-02	2.589E 01	2.979E 01	5.588E-06	8.267E-06
1	1	2.500E 01	4.171E-02	2.792E-02	2.589E 01	2.979E 01	5.588E-06	8.267E-06
10	1	0.0	4.290E-02	2.967E-02	2.695E 01	3.028E 01	6.243E-06	8.659E-06
10	1	2.500E 01	4.305E-02	2.983E-02	2.695E 01	3.028E 01	6.243E-06	8.659E-06
20	1	0.0	4.455E-02	3.183E-02	2.814E 01	3.085E 01	7.041E-06	9.135E-06
20	1	2.500E 01	4.472E-02	3.206E-02	2.814E 01	3.085E 01	7.041E-06	9.135E-06
30	1	0.0	4.640E-02	3.419E-02	2.932E 01	3.158E 01	7.904E-06	9.766E-06
30	1	2.500E 01	4.660E-02	3.443E-02	2.932E 01	3.158E 01	7.904E-06	9.766E-06
40	1	0.0	4.848E-02	3.671E-02	3.053E 01	3.236E 01	8.869E-06	1.048E-05
40	1	2.500E 01	4.871E-02	3.697E-02	3.053E 01	3.236E 01	8.869E-06	1.048E-05
50	1	0.0	5.082E-02	3.941E-02	3.177E 01	3.317E 01	9.942E-06	1.127E-05
50	1	2.500E 01	5.107E-02	3.970E-02	3.177E 01	3.317E 01	9.942E-06	1.127E-05
60	1	0.0	5.343E-02	4.232E-02	3.301E 01	3.397E 01	1.111E-05	1.210E-05
60	1	2.500E 01	5.371E-02	4.263E-02	3.301E 01	3.397E 01	1.111E-05	1.210E-05
70	1	0.0	5.636E-02	4.545E-02	3.428E 01	3.485E 01	1.243E-05	1.306E-05
70	1	2.500E 01	5.667E-02	4.578E-02	3.428E 01	3.485E 01	1.243E-05	1.306E-05
80	1	0.0	5.963E-02	4.884E-02	3.561E 01	3.581E 01	1.394E-05	1.418E-05
80	1	2.500E 01	5.998E-02	4.919E-02	3.561E 01	3.581E 01	1.394E-05	1.418E-05
90	1	0.0	6.331E-02	5.253E-02	3.699E 01	3.685E 01	1.567E-05	1.549E-05
90	1	2.500E 01	6.370E-02	5.291E-02	3.699E 01	3.685E 01	1.567E-05	1.549E-05
100	1	0.0	6.744E-02	5.657E-02	3.844E 01	3.800E 01	1.768E-05	1.705E-05
100	1	2.500E 01	6.788E-02	5.699E-02	3.844E 01	3.800E 01	1.768E-05	1.705E-05
110	1	0.0	7.212E-02	6.103E-02	3.998E 01	3.926E 01	2.006E-05	1.892E-05
110	1	2.500E 01	7.262E-02	6.151E-02	3.998E 01	3.926E 01	2.006E-05	1.892E-05
120	1	0.0	7.744E-02	6.601E-02	4.161E 01	4.066E 01	2.291E-05	2.120E-05
120	1	2.500E 01	7.802E-02	6.654E-02	4.161E 01	4.066E 01	2.291E-05	2.120E-05
130	1	0.0	8.355E-02	7.161E-02	4.338E 01	4.221E 01	2.640E-05	2.405E-05
130	1	2.500E 01	8.421E-02	7.222E-02	4.338E 01	4.221E 01	2.640E-05	2.405E-05
140	1	0.0	9.062E-02	7.802E-02	4.530E 01	4.397E 01	3.079E-05	2.768E-05
140	1	2.500E 01	9.139E-02	7.871E-02	4.530E 01	4.397E 01	3.079E-05	2.768E-05
150	1	0.0	9.893E-02	8.544E-02	4.742E 01	4.595E 01	3.649E-05	3.243E-05
150	1	2.500E 01	9.984E-02	8.625E-02	4.742E 01	4.595E 01	3.649E-05	3.243E-05
160	1	0.0	1.089E-01	9.423E-02	4.981E 01	4.821E 01	4.421E-05	3.887E-05
160	1	2.500E 01	1.100E-01	9.520E-02	5.006E 01	4.845E 01	4.510E-05	3.962E-05
170	1	0.0	1.211E-01	1.049E-01	5.257E 01	5.087E 01	5.530E-05	4.815E-05
170	1	2.500E 01	1.225E-01	1.061E-01	5.284E 01	5.113E 01	5.650E-05	4.915E-05
180	1	0.0	1.368E-01	1.185E-01	5.587E 01	5.411E 01	7.274E-05	6.274E-05
180	1	2.500E 01	1.386E-01	1.201E-01	5.615E 01	5.438E 01	7.447E-05	6.420E-05
190	1	0.0	1.582E-01	1.370E-01	6.005E 01	5.828E 01	1.046E-04	8.948E-05
190	1	2.500E 01	1.609E-01	1.392E-01	6.035E 01	5.859E 01	1.075E-04	9.187E-05
200	1	0.0	1.921E-01	1.658E-01	6.605E 01	6.443E 01	1.856E-04	1.577E-04
200	1	2.500E 01	1.969E-01	1.698E-01	6.671E 01	6.512E 01	1.986E-04	1.688E-04
210	1	0.0	3.028E-01	2.616E-01	8.297E 01	8.263E 01	2.620E-03	2.385E-03

LIMIT LOAD FRACTURE OCCURS IN THE 189 BLOCK 1 STEP AFTER 1.570E 01 CYCLES

CRITICAL K AT DEPTH HAS BEEN EXCEEDED IN THE 210 BLOCK AND THE 1 STEP AFTER 6.695E 00 CYCLES

ITERATION RESULTS

THICKNESS	A	C	LIFE	PERCENT OF REQUIRED LIFE
5.000E-01	5.000E-02	7.500E-02	1.109E 02	55.43
5.000E-01	2.772E-02	4.158E-02	2.093E 02	104.63

RUN 2 OF 2 RUNS D6AC ITERATION ON CRACK SIZE / PROOF TEST

LOAD INPUT DATA

STRESS FACTOR 1.000E 00
LIMIT STRESS 1.800E 02

STEP	MAX STRESS	MIN STRESS	UNITS(CYCLES)	MATERIAL TYPE
1	1.200E 02	0.0	2.500E 01	1

GEOMETRY INPUT DATA

CRACK TYPE	PTC - 1
WIDTH	9.900E 01
ADDITIONAL DIMENSION	0.0
RADIUS/NOTCH DEPTH	0.0
THICKNESS	5.000E-01
CRACK DEPTH	2.772E-02
HALF CRACK LENGTH	4.158E-02

MATERIAL INPUT DATA

MATERIAL TYPE	YIELD STRENGTH	GROWTH EQUATION	RETARDATION MODEL	CRITICAL STRESS INTENSITY (SURFACE)	THRESHOLD STRESS INTENSITY (SURFACE)	CRITICAL STRESS INTENSITY (DEPTH)	THRESHOLD STRESS INTENSITY (DEPTH)
1	1.900E 02	1	0	9.000E 01	6.000E 00	9.000E 01	6.000E 00

		EQUATION CONSTANTS			
CONSTANT NUMBER	MATERIAL TYPE	CRACK GROWTH RATE SURFACE	CRACK GROWTH RATE DEPTH	RETARDATION MODEL SURFACE	RETARDATION MODEL DEPTH
1	1	7.500E-10	7.500E-10	0.0	0.0
2	1	2.740E 00	2.740E 00	0.0	0.0
3	1	9.000E 01	9.000E 01	0.0	0.0
4	1	6.000E 00	6.000E 00	0.0	0.0

PROOF INPUT DATA

PROOF TYPE	1	LOWER A	0.0
PROOF	1.800E 02	UPPER A	5.000E-01
KC PROOF	7.000E 01	A/C	3.330E-01
KA PROOF	9.000E 01	ITERATION LIMIT	100

RUN 2 U6AC ITERATION ON CRACK SIZE / PROOF TEST

CRACK IS A PART THRU CRACK

BLOCK	STEP	CYCLES	HALF SURFACE CRACK LENGTH (IN)	CRACK DEPTH (IN)	KMAX-SURFACE (KSI ROOT-IN)	KMAX-DEPTH (KSI ROOT-IN)	SURFACE GROWTH RATE (IN/CYCLE)	DEPTH GROWTH RATE (IN/CYCLE)
1	1	0.0	2.119E-01	7.057E-02	3.375E 01	6.009E 01	1.187E-05	1.049E-04
1	1	2.500E 01	2.122E-01	7.325E-02	3.461E 01	6.061E 01	1.280E-05	1.100E-04
10	1	0.0	2.161E-01	1.017E-01	4.495E 01	6.584E 01	2.994E-05	1.819E-04
10	1	2.500E 01	2.169E-01	1.064E-01	4.641E 01	6.636E 01	3.366E-05	1.915E-04
20	1	0.0	2.332E-01	1.633E-01	6.346E 01	7.133E 01	1.435E-04	3.343E-04
20	1	2.500E 01	2.371E-01	1.719E-01	6.549E 01	7.204E 01	1.752E-04	3.649E-04

LIMIT LOAD FRACTURE OCCURS IN THE 1 BLOCK 1 STEP AFTER 0.0 CYCLES

CRITICAL K AT DEPTH HAS BEEN EXCEEDED IN THE 26 BLOCK AND THE 1 STEP AFTER 1.289E 01 CYCLES

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            1111111111222222222233333333334444444444555555555566666666667777777778
   12345678901234567890123456789012345678901234567890123456789012345678901234567890
  1D6AC   PIN LOADED LUG WITH PLOTTING
  2   1  1000  10   1
  3 1.          0   1   1   1                                   1 500.
  4   1   0 75.
  5 50.       0.        1000.       1
  6   1  11
  7 6.        .5        .1        .1       30.        .5
 15   1
 16 190.        1   C   0 90.      6.        90.        6.
 23   7.5E-10
 23   2.74
 23   90.
 23   6.                                                                        END
            1111111111222222222233333333334444444444555555555566666666667777777778
   12345678901234567890123456789012345678901234567890123456789012345678901234567890
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Card Type

Column Number

RUN 1 OF 1 RUNS DSAC PIN LOADED LUG WITH PLOTTING

LOAD INPUT DATA

STRESS FACTOR 1.000E 00
LIMIT STRESS 7.500E 01

STEP	MAX STRESS	MIN STRESS	UNITS(CYCLES)	MATERIAL TYPE
1	5.000E 01	0.0	1.000E 03	1

GEOMETRY INPUT DATA

CRACK TYPE	PTC - 11
WIDTH	6.000E 00
ADDITIONAL DIMENSION	3.000E 01
RADIUS/NOTCH DEPTH	5.000E-01
THICKNESS	5.000E-01
CRACK DEPTH	1.000E-01
HALF CRACK LENGTH	1.000E-01

MATERIAL INPUT DATA

MATERIAL TYPE	YIELD STRENGTH	GROWTH EQUATION	RETARDATION MODEL	CRITICAL STRESS INTENSITY (SURFACE)	THRESHOLD STRESS INTENSITY (SURFACE)	CRITICAL STRESS INTENSITY (DEPTH)	THRESHOLD STRESS INTENSITY (DEPTH)
1	1.900E 02	1	0	9.000E 01	6.000E 00	9.000E 01	6.000E 00

==============EQUATION CONSTANTS=============

CONSTANT NUMBER	MATERIAL TYPE	CRACK GROWTH RATE SURFACE	CRACK GROWTH RATE DEPTH	RETARDATION MODEL SURFACE	RETARDATION MODEL DEPTH
1	1	7.500E-10	7.500E-10	0.0	0.0
2	1	2.740E 00	2.740E 00	0.0	0.0
3	1	9.000E 01	9.000E 01	0.0	0.0
4	1	6.000E 00	6.000E 00	0.0	0.0

RUN 1 D6AC PIN LOADED LUG WITH PLOTTING

CRACK IS A PART THRU CRACK

BLOCK	STEP	CYCLES	HALF SURFACE CRACK LENGTH (IN)	CRACK DEPTH (IN)	KMAX-SURFACE (KSI ROOT-IN)	KMAX-DEPTH (KSI ROOT-IN)	SURFACE GROWTH RATE (IN/CYCLE)	DEPTH GROWTH RATE (IN/CYCLE)
1	1	0.0	1.000E-01	1.000E-01	3.205E 01	3.690E 01	1.020E-05	1.555E-05
1	1	1.000E 03	1.102E-01	1.158E-01	3.207E 01	3.727E 01	1.021E-05	1.605E-05

ORIGINAL PAGE IS OF POOR QUALITY

RUN 1 D6AC PIN LOADED LUG WITH PLOTTING

CRACK IS A CRACK IN TRANSITION

BLOCK	STEP	CYCLES	HALF FRONT CRACK LENGTH (IN)	HALF BACK CRACK LENGTH (IN)	KMAX-FRONT (KSI ROOT-IN)	KMAX-BACK (KSI ROOT-IN)	FRONT GROWTH RATE (IN/CYCLE)	BACK GROWTH RATE (IN/CYCLE)
9	1	7.066E 02	1.885E-01	1.269E-01	5.532E 01	8.864E 01	6.966E-05	6.166E-02

RUN 1 F6AC PIN LOADFD LUG WITH PLOTTING

CRACK IS A THROUGH CRACK

BLOCK	STEP	CYCLES	HALF CRACK LENGTH (IN)	KMAX (KSI ROOT-IN)	CRACK GROWTH RATE (IN/CYCLE)
9	1	3.184E 02	1.963E-01	5.543E 01	7.006E-05
9	1	1.000E 03	2.091E-01	5.545E 01	7.020E-05
10	1	0.0	2.091E-01	5.545E 01	7.020E-05
10	1	1.000E 03	2.797E-01	5.559E 01	7.105E-05
20	1	0.0	1.227E 00	6.955E 01	2.707E-04

LIMIT LOAD FRACTURE OCCURS IN THE 9 RLOCK 1 STEP AFTER 8.085E 02 CYCLES

CRITICAL K AT SURFACE HAS BEEN EXCEEDED IN THE 20 BLOCK AND THF 1 STEP AFTFR 7.241E 02 CYCLES

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TITL              D6AC   PIN LOADED LUG WITH PLOTTING                  1.000E 03
DATA   1.000E-01   1.000E-01   0.0
DATA   1.094E-01   1.061E-01   5.285E 02
DATA   1.158E-01   1.102E-01   1.000E 03
DATA   1.254E-01   1.163E-01   1.516E 03
DATA   1.321E-01   1.204E-01   2.000E 03
DATA   1.430E-01   1.271E-01   2.573E 03
DATA   1.488E-01   1.306E-01   3.000E 03
DATA   1.595E-01   1.371E-01   3.536E 03
DATA   1.659E-01   1.409E-01   4.000E 03
DATA   1.779E-01   1.479E-01   4.588E 03
DATA   1.833E-01   1.511E-01   5.000E 03
DATA   1.946E-01   1.576E-01   5.530E 03
DATA   2.010E-01   1.613E-01   6.000E 03
DATA   2.134E-01   1.683E-01   6.573E 03
DATA   2.190E-01   1.714E-01   7.000E 03
DATA   2.324E-01   1.789E-01   7.617E 03
DATA   7.371E-01   1.815E-01   8.000E 03
DATA   2.492E-01   1.881E-01   8.527E 03
DATA   2.525E-01   2.091E-01   9.000E 03
DATA   2.525E-01   2.476E-01   9.513E 03
DATA   2.525E-01   2.797E-01   1.000E 04
DATA   2.525E-01   3.215E-01   1.054E 04
DATA   2.525E-01   3.514E-01   1.100E 04
DATA   2.525E-01   3.920E-01   1.150E 04
DATA   2.525E-01   4.252E-01   1.200E 04
DATA   2.525E-01   4.697E-01   1.252E 04
DATA   2.525E-01   5.024E-01   1.300E 04
DATA   2.525E-01   5.494E-01   1.352E 04
DATA   2.525E-01   5.844E-01   1.400E 04
DATA   2.525E-01   6.391E-01   1.456E 04
DATA   2.525E-01   6.732E-01   1.500E 04
DATA   2.525E-01   7.289E-01   1.551E 04
DATA   2.525E-01   7.719E-01   1.600E 04
DATA   2.525E-01   8.359E-01   1.651E 04
DATA   2.525E-01   8.858E-01   1.700E 04
DATA   2.525E-01   9.688E-01   1.755E 04
DATA   2.525E-01   1.027E 00   1.800E 04
DATA   2.525E-01   1.134E 00   1.854E 04
DATA   2.525E-01   1.227E 00   1.900E 04
DATA   2.525E-01   1.425E 00   1.951E 04
DATA   2.525E-01   1.739E 00   1.972E 04
HDRS
HDR1     CRITICAL K AT SURFACE EXCEEDED
HDR2    20 BLOCK     1 STEP 7.241E 02 CYCLE
HDR3         TOTAL CYCLES = 1.972E 04
HDR4
HDR5
HDR6
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```
            1111111111222222222233333333334444444444555555555566666666667777777778
   12345678901234567890123456789012345678901234567890123456789012345678901234567890

 1 TABULAR INPUT EXAMPLES
 2    3  1000  10   1
 3  1.           0   1   1   1
 4    1    0 180.
 5  120.      0.        25.         1
 6    1    1
 7  99.       .5        .075      .05
15    1
16  190.        4    0   0 90.      6.        90.       6.
17  6.
17  8.
17  10.
17  12.
17  16.
17  30.
17  84.
17  90.                                                        Run 1           END
18  0.
18  .3
18  .5                                                                         END
19      1.E-13    3.E-13    4.E-13
19      1.E-09    3.E-09    4.E-09
19      1.E-08    3.E-08    4.E-08
19      1.E-07    3.E-07    4.E-07
19     2.4E-06   7.2E-06    1.E-05
19      9.E-06   2.7E-05    4.E-05
19      5.E-05   1.5E-04    2.E-04
19      1.E-02    3.E-02    4.E-02
 3  1.           0   0   1   0
 6    3    7
 7  99.       .5        .075
 8    2
 9  0.
 9  1.
 9  1.2
 9  1.5
 9  1.7
 9  1.8
 9  2.
 9  3.                                                         Run 2
 9  100.                                                                       END
11  1.
11  1.
11  .9
11  .7
11  .65
11  .7
11  .8
11  1.1
11  1.1

            1111111111222222222233333333334444444444555555555566666666667777777778
   12345678901234567890123456789012345678901234567890123456789012345678901234567890
```

Card Type

Column Number

Card Type	Cols 1–10	11–20	21–30	31–40	41–50	51–60	61–70	71–80	
9	0.								
9	1.								
9	1.2								
9	1.5								
9	1.7								
9	1.8								
9	2.								
9	3.								
9	100.							END	
11	1.								Run 2
11	1.								
11	1.2								
11	2.								
11	3.								
11	10.								
11	1.E+15								
11	1.E+15								
11	1.E+15								
3	1.	0 0	1 0						
6	1 7								
7	99.	.5	.075	.05					
8	1								
9	0.								
9	.1								
9	.2								
9	.4								
9	.6								
9	.8								
9	1.								
9	2.								
9	10.							END	
10	0.								
10	.1								
10	.2								
10	.3								
10	.4								
10	.48								Run 3
10	.5							END	
11	1.	1.	1.1	1.2	1.3	2.	100.		
11	1.	1.	1.2	1.3	1.4	2.4	120.		
11	1.1	1.1	1.2	1.4	1.6	3.	160.		
11	1.3	1.3	1.4	1.5	1.8	4.	180.		
11	1.7	1.7	1.9	2.2	2.5	5.	200.		
11	2.	2.	2.5	3.	5.	6.	250.		
11	4.	4.	6.	8.	10.	15.	300.		
11	10.	10.	15.	20.	30.	40.	350.		
11	100.	100.	200.	300.	350.	400.	400.		
12	0.								
12	.2								
12	.4								

Card Type

Column Number

```
         11111111112222222222333333333344444444445555555555666666666677777777778
12345678901234567890123456789012345678901234567890123456789012345678901234567890

12.8
121.2
121.6
122.
124.
1220.                                                                       END
130.
13.1
13.2
13.3
13.4                                                                Run 3
13.48
13.5                                                                        END
141.1           1.1       1.1       1.2       1.3       2.        100.
141.1           1.1       1.2       1.3       1.4       2.4       120.
141.1           1.1       1.2       1.4       1.6       3.        160.
141.3           1.3       1.4       1.5       1.8       4.        180.
141.7           1.7       1.9       2.2       2.5       5.        200.
142.            2.        2.5       3.        5.        6.        250.
144.            4.        6.        8.        10.       15.       300.
1410.           10.       15.       20.       30.       40.       350.
14100.          100.      200.      300.      350.      400.      400.

         11111111112222222222333333333344444444445555555555666666666677777777778
12345678901234567890123456789012345678901234567890123456789012345678901234567890
```

Card Type   Column Number

RUN 1 OF 3 RUNS — TABULAR INPUT EXAMPLES

LOAD INPUT DATA

STRESS FACTOR 1.000E 00
LIMIT STRESS 1.800E 02

STEP	MAX STRESS	MIN STRESS	UNITS(CYCLES)	MATERIAL TYPE
1	1.200E 02	0.0	2.500E 01	1

GEOMETRY INPUT DATA

CRACK TYPE	PTC - 1
WIDTH	9.900E 01
ADDITIONAL DIMENSION	0.0
RADIUS/NOTCH DEPTH	0.0
THICKNESS	5.000E-01
CRACK DEPTH	5.000E-02
HALF CRACK LENGTH	7.500E-02

MATERIAL INPUT DATA

MATERIAL TYPE	YIELD STRENGTH	GROWTH EQUATION	RETARDATION MODEL	CRITICAL STRESS INTENSITY (SURFACE)	THRESHOLD STRESS INTENSITY (SURFACE)	CRITICAL STRESS INTENSITY (DEPTH)	THRESHOLD STRESS INTENSITY (DEPTH)
1	1.900E 02	4	0	9.000E 01	6.000E 00	9.000E 01	6.000E 00

MATERIAL TYPE 1 TABLE 7

	RE= 0.0	3.000E-01	5.000E-01	1.000E 00
DKE= 6.000E 00	1.000E-13	3.000E-13	4.000E-13	4.000E-13
DKE= 8.000E 00	1.000E-09	3.000E-09	4.000E-09	4.000E-09
DKE= 1.000E 01	1.000E-08	3.000E-08	4.000E-08	4.000E-08
DKE= 1.200E 01	1.000E-07	3.000E-07	4.000E-07	4.000E-07
DKE= 1.600E 01	2.400E-06	7.200E-06	1.000E-05	1.000E-05
DKE= 3.000E 01	9.000E-06	2.700E-05	4.000E-05	4.000E-05
DKE= 8.400E 01	5.000E-05	1.500E-04	2.000E-04	2.000E-04
DKE= 9.000E 01	1.000E-02	3.000E-02	4.000E-02	4.000E-02

MATERIAL TYPE 1 TABLE 8

	RE= 0.0	3.000E-01	5.000E-01	1.000E 00
DKE= 6.000E 00	1.000E-13	3.000E-13	4.000E-13	4.000E-13
DKE= 8.000E 00	1.000E-09	3.000E-09	4.000E-09	4.000E-09
DKE= 1.000E 01	1.000E-08	3.000E-08	4.000E-08	4.000E-08
DKE= 1.200E 01	1.000E-07	3.000E-07	4.000E-07	4.000E-07
DKE= 1.600E 01	2.400E-06	7.200E-06	1.000E-05	1.000E-05
DKE= 3.000E 01	9.000E-06	2.700E-05	4.000E-05	4.000E-05
DKE= 8.400E 01	5.000E-05	1.500E-04	2.000E-04	2.000E-04
DKE= 9.000E 01	1.000E-02	3.000E-02	4.000E-02	4.000E-02

RUN 1 TABULAR INPUT EXAMPLES

CRACK IS A PART THRU CRACK

BLOCK	STEP	CYCLES	HALF SURFACE CRACK LENGTH (IN)	CRACK DEPTH (IN)	KMAX-SURFACE (KSI ROOT-IN)	KMAX-DEPTH (KSI ROOT-IN)	SURFACE GROWTH RATE (IN/CYCLE)	DEPTH GROWTH RATE (IN/CYCLE)
1	1	0.0	7.500E-02	5.000E-02	3.477E 01	4.007E 01	1.151E-05	1.457E-05
1	1	2.500E 01	7.529E-02	5.036E-02	3.477E 01	4.007E 01	1.151E-05	1.457E-05
10	1	0.0	7.766E-02	5.332E-02	3.612E 01	4.080E 01	1.226E-05	1.502E-05
10	1	2.500E 01	7.797E-02	5.370E-02	3.612E 01	4.080E 01	1.226E-05	1.502E-05
20	1	0.0	8.082E-02	5.713E-02	3.761E 01	4.162E 01	1.312E-05	1.553E-05
20	1	2.500E 01	8.115E-02	5.752E-02	3.761E 01	4.162E 01	1.312E-05	1.553E-05
30	1	0.0	8.420E-02	6.108E-02	3.908E 01	4.253E 01	1.398E-05	1.610E-05
30	1	2.500E 01	8.455E-02	6.148E-02	3.908E 01	4.253E 01	1.398E-05	1.610E-05
40	1	0.0	8.779E-02	6.517E-02	4.054E 01	4.353E 01	1.486E-05	1.673E-05
40	1	2.500E 01	8.817E-02	6.559E-02	4.054E 01	4.353E 01	1.486E-05	1.673E-05
50	1	0.0	9.161E-02	6.943E-02	4.200E 01	4.455E 01	1.576E-05	1.739E-05
50	1	2.500E 01	9.200E-02	6.986E-02	4.200E 01	4.455E 01	1.576E-05	1.739E-05
60	1	0.0	9.565E-02	7.385E-02	4.346E 01	4.558E 01	1.669E-05	1.806E-05
60	1	2.500E 01	9.607E-02	7.430E-02	4.346E 01	4.558E 01	1.669E-05	1.806E-05
70	1	0.0	9.993E-02	7.843E-02	4.488E 01	4.656E 01	1.761E-05	1.871E-05
70	1	2.500E 01	1.004E-01	7.890E-02	4.488E 01	4.656E 01	1.761E-05	1.871E-05
80	1	0.0	1.044E-01	8.319E-02	4.631E 01	4.756E 01	1.855E-05	1.939E-05
80	1	2.500E 01	1.049E-01	8.367E-02	4.631E 01	4.756E 01	1.855E-05	1.939E-05
90	1	0.0	1.092E-01	8.811E-02	4.774E 01	4.859E 01	1.951E-05	2.009E-05
90	1	2.500E 01	1.097E-01	8.861E-02	4.774E 01	4.859E 01	1.951E-05	2.009E-05
100	1	0.0	1.142E-01	9.322E-02	4.917E 01	4.965E 01	2.050E-05	2.083E-05
100	1	2.500E 01	1.147E-01	9.374E-02	4.917E 01	4.965E 01	2.050E-05	2.083E-05
110	1	0.0	1.194E-01	9.851E-02	5.062E 01	5.074E 01	2.151E-05	2.160E-05
110	1	2.500E 01	1.199E-01	9.905E-02	5.062E 01	5.074E 01	2.151E-05	2.160E-05
120	1	0.0	1.249E-01	1.040E-01	5.207E 01	5.186E 01	2.255E-05	2.239E-05
120	1	2.500E 01	1.255E-01	1.046E-01	5.207E 01	5.186E 01	2.255E-05	2.239E-05
130	1	0.0	1.307E-01	1.097E-01	5.353E 01	5.301E 01	2.361E-05	2.323E-05
130	1	2.500E 01	1.312E-01	1.103E-01	5.353E 01	5.301E 01	2.361E-05	2.323E-05
140	1	0.0	1.367E-01	1.156E-01	5.501E 01	5.419E 01	2.470E-05	2.410E-05
140	1	2.500E 01	1.373E-01	1.162E-01	5.501E 01	5.419E 01	2.470E-05	2.410E-05
150	1	0.0	1.430E-01	1.217E-01	5.650E 01	5.540E 01	2.583E-05	2.500E-05
150	1	2.500E 01	1.436E-01	1.223E-01	5.650E 01	5.540E 01	2.583E-05	2.500E-05
160	1	0.0	1.496E-01	1.281E-01	5.800E 01	5.665E 01	2.698E-05	2.594E-05
160	1	2.500E 01	1.502E-01	1.287E-01	5.800E 01	5.665E 01	2.698E-05	2.594E-05
170	1	0.0	1.564E-01	1.347E-01	5.951E 01	5.796E 01	2.816E-05	2.695E-05
170	1	2.500E 01	1.571E-01	1.353E-01	5.951E 01	5.796E 01	2.816E-05	2.695E-05
180	1	0.0	1.636E-01	1.415E-01	6.104E 01	5.929E 01	2.938E-05	2.799E-05
180	1	2.500E 01	1.644E-01	1.422E-01	6.104E 01	5.929E 01	2.938E-05	2.799E-05
190	1	0.0	1.711E-01	1.486E-01	6.259E 01	6.066E 01	3.063E-05	2.908E-05
190	1	2.500E 01	1.719E-01	1.494E-01	6.259E 01	6.066E 01	3.063E-05	2.908E-05
200	1	0.0	1.789E-01	1.560E-01	6.416E 01	6.207E 01	3.192E-05	3.021E-05
200	1	2.500E 01	1.797E-01	1.568E-01	6.416E 01	6.207E 01	3.192E-05	3.021E-05
210	1	0.0	1.870E-01	1.637E-01	6.575E 01	6.351E 01	3.325E-05	3.138E-05
210	1	2.500E 01	1.879E-01	1.645E-01	6.575E 01	6.351E 01	3.325E-05	3.138E-05
220	1	0.0	1.955E-01	1.717E-01	6.736E 01	6.499E 01	3.462E-05	3.261E-05
220	1	2.500E 01	1.964E-01	1.725E-01	6.736E 01	6.499E 01	3.462E-05	3.261E-05
230	1	0.0	2.043E-01	1.800E-01	6.900E 01	6.650E 01	3.603E-05	3.389E-05
230	1	2.500E 01	2.052E-01	1.808E-01	6.900E 01	6.650E 01	3.603E-05	3.389E-05
240	1	0.0	2.135E-01	1.886E-01	7.065E 01	6.806E 01	3.748E-05	3.522E-05
240	1	2.500E 01	2.144E-01	1.895E-01	7.065E 01	6.806E 01	3.748E-05	3.522E-05
250	1	0.0	2.230E-01	1.976E-01	7.234E 01	6.966E 01	3.898E-05	3.661E-05
250	1	2.500E 01	2.240E-01	1.985E-01	7.234E 01	6.966E 01	3.898E-05	3.661E-05
260	1	0.0	2.329E-01	2.069E-01	7.405E 01	7.131E 01	4.053E-05	3.806E-05

260	1	2.500F 01	2.339E-01	2.078E-01	7.405E 01	7.131E 01	4.053E-05	3.806E-05
270	1	0.0	2.432E-01	2.166E-01	7.578E 01	7.301E 01	4.212E-05	3.958E-05
270	1	2.500E 01	2.443E-01	2.176E-01	7.578E 01	7.301E 01	4.212E-05	3.958E-05
280	1	0.0	2.540E-01	2.266E-01	7.755E 01	7.475E 01	4.377E-05	4.117E-05
280	1	2.500F 01	2.551E-01	2.277E-01	7.755E 01	7.475E 01	4.377E-05	4.117E-05
290	1	0.0	2.651E-01	2.371E-01	7.934E 01	7.656E 01	4.547E-05	4.284E-05
290	1	2.500E 01	2.662E-01	2.382E-01	7.934E 01	7.656E 01	4.547E-05	4.284E-05
300	1	0.0	2.767E-01	2.480E-01	8.117E 01	7.842E 01	4.723E-05	4.459E-05
300	1	2.500E 01	2.778E-01	2.491E-01	8.117E 01	7.842E 01	4.723E-05	4.459E-05
310	1	0.0	2.887E-01	2.594E-01	8.303E 01	8.035E 01	4.904E-05	4.644E-05
310	1	2.500F 01	2.899E-01	2.605E-01	8.303E 01	8.035E 01	4.904E-05	4.644E-05
320	1	0.0	3.036E-01	2.712F-01	8.484E 01	8.276E 01	1.076E-04	4.878E-05
320	1	2.500E 01	3.063E-01	2.724E-01	8.484E 01	8.276E 01	1.076E-04	4.878E-05

LIMIT LOAD FRACTURE OCCURS IN THE 173 BLOCK 1 STEP AFTER 0.0 CYCLES

CRITICAL K AT DEPTH HAS BEEN EXCEEDED IN THE 326 BLOCK AND THE 1 STEP AFTER 1.233E 01 CYCLES

LOAD INPUT DATA

STRESS FACTOR	1.000E 00
LIMIT STRESS	1.800E 02

STEP	MAX STRESS	MIN STRESS	UNITS(CYCLES)	MATERIAL TYPE
1	1.200E 02	0.0	2.500E 01	1

GEOMETRY INPUT DATA

CRACK TYPE	TC - 7
WIDTH	9.900E 01
ADDITIONAL DIMENSION	0.0
RADIUS/NOTCH DEPTH	0.0
THICKNESS	5.000E-01
HALF CRACK LENGTH	7.500E-02

TABLE 1: BETA C

	A= 0.0	1.000E 00
C= 0.0	1.000E 00	1.000E 00
C= 1.000E 00	1.000E 00	1.000E 00
C= 1.200E 00	9.000E-01	9.000E-01
C= 1.500E 00	7.000E-01	7.000E-01
C= 1.700E 00	6.500E-01	6.500E-01
C= 1.800E 00	7.000E-01	7.000E-01
C= 2.000E 00	8.000E-01	8.000E-01
C= 3.000E 00	1.100E 00	1.100E 00
C= 1.000E 02	1.100E 00	1.100E 00

TABLE 2: BETA A

	A= 0.0
C= 0.0	0.0

TABLE 3: BETA C

	A= 0.0	1.000E 00
C= 0.0	1.000E 00	1.000E 00
C= 1.000E 00	1.000E 00	1.000E 00
C= 1.200E 00	1.200E 00	1.200E 00
C= 1.500E 00	2.000E 00	2.000E 00
C= 1.700E 00	3.000E 00	3.000E 00
C= 1.800E 00	1.000E 01	1.000E 01
C= 2.000E 00	1.000E 15	1.000E 15
C= 3.000E 00	1.000E 15	1.000E 15
C= 1.000E 02	1.000E 15	1.000E 15

TABLE 4: BETA A

	A= 0.0
C= 0.0	0.0

MATERIAL INPUT DATA

MATERIAL TYPE	YIELD STRENGTH	GROWTH EQUATION	RETARDATION MODEL	CRITICAL STRESS INTENSITY (SURFACE)	THRESHOLD STRESS INTENSITY (SURFACE)	CRITICAL STRESS INTENSITY (DEPTH)	THRESHOLD STRESS INTENSITY (DEPTH)
1	1.900E 02	4	0	9.000E 01	6.000E 00	9.000E 01	6.000E 00

MATERIAL TYPE 1 TABLE 7

RE=	0.0	3.000E-01	5.000E-01	1.000E 00
DKE= 6.000E 00	1.000E-13	3.000E-13	4.000E-13	4.000E-13
DKE= 8.000E 00	1.000E-09	3.000E-09	4.000E-09	4.000E-09
DKE= 1.000E 01	1.000E-08	3.000E-08	4.000E-08	4.000E-08
DKE= 1.200E 01	1.000E-07	3.000E-07	4.000E-07	4.000E-07
DKE= 1.600E 01	2.400E-06	7.200E-06	1.000E-05	1.000E-05
DKE= 3.000E 01	9.000E-06	2.700E-05	4.000E-05	4.000E-05
DKE= 8.400E 01	5.000E-05	1.500E-04	2.000E-04	2.000E-04
DKE= 9.000E 01	1.000E-02	3.000E-02	4.000E-02	4.000E-02

MATERIAL TYPE 1 TABLE 8

RE=	0.0	3.000E-01	5.000E-01	1.000E 00
DKE= 6.000E 00	1.000E-13	3.000E-13	4.000E-13	4.000E-13
DKE= 8.000E 00	1.000E-09	3.000E-09	4.000E-09	4.000E-09
DKE= 1.000E 01	1.000E-08	3.000E-08	4.000E-08	4.000E-08
DKE= 1.200E 01	1.000E-07	3.000E-07	4.000E-07	4.000E-07
DKE= 1.600E 01	2.400E-06	7.200E-06	1.000E-05	1.000E-05
DKE= 3.000E 01	9.000E-06	2.700E-05	4.000E-05	4.000E-05
DKE= 8.400E 01	5.000E-05	1.500E-04	2.000E-04	2.000E-04
DKE= 9.000E 01	1.000E-02	3.000E-02	4.000E-02	4.000E-02

RUN 2 TABULAR INPUT EXAMPLES

CRACK IS A THROUGH CRACK

BLOCK	STEP	CYCLES	HALF CRACK LENGTH (IN)	KMAX (KSI ROOT-IN)	CRACK GROWTH RATE (IN/CYCLE)
1	1	0.0	7.500E-02	5.839E 01	2.729E-05
1	1	2.500E 01	7.568E-02	5.839E 01	2.729E-05
10	1	0.0	8.133E-02	6.081E 01	2.919E-05
10	1	2.500E 01	8.206E-02	6.081E 01	2.919E-05
20	1	0.0	8.887E-02	6.357E 01	3.143E-05
20	1	2.500E 01	8.966E-02	6.357E 01	3.143E-05
30	1	0.0	9.699E-02	6.641E 01	3.380E-05
30	1	2.500E 01	9.784E-02	6.641E 01	3.380E-05
40	1	0.0	1.057E-01	6.933E 01	3.632E-05
40	1	2.500E 01	1.066E-01	6.933E 01	3.632E-05
50	1	0.0	1.151E-01	7.234E 01	3.898E-05
50	1	2.500E 01	1.161E-01	7.234E 01	3.898E-05
60	1	0.0	1.252E-01	7.543E 01	4.180E-05
60	1	2.500E 01	1.262E-01	7.543E 01	4.180E-05
70	1	0.0	1.359E-01	7.862E 01	4.478E-05
70	1	2.500E 01	1.371E-01	7.862E 01	4.478E-05
80	1	0.0	1.475E-01	8.189E 01	4.792E-05
80	1	2.500E 01	1.487E-01	8.189E 01	4.792E-05
90	1	0.0	1.674E-01	8.724E 01	9.142E-04

LIMIT LOAD FRACTURE OCCURS IN THE 7 BLOCK 1 STEP AFTER 0.0 CYCLES

CRITICAL K AT SURFACE HAS BEEN EXCEEDED IN THE 90 BLOCK AND THE 1 STEP AFTER 5.458E 00 CYCLES

ORIGINAL PAGE IS OF POOR QUALITY

RUN 3 OF 3 RUNS TABULAR INPUT EXAMPLES

LOAD INPUT DATA

STRESS FACTOR 1.000E 00
LIMIT STRESS 1.800E 02

STEP	MAX STRESS	MIN STRESS	UNITS(CYCLES)	MATERIAL TYPE
1	1.200E 02	0.0	2.500E 01	1

GEOMETRY INPUT DATA

CRACK TYPE	PTC - 7
WIDTH	9.900E 01
ADDITIONAL DIMENSION	0.0
RADIUS/NOTCH DEPTH	0.0
THICKNESS	5.000E-01
CRACK DEPTH	5.000E-02
HALF CRACK LENGTH	7.500E-02

TABLE 1: BETA C

	A= 0.0	1.000E-01	2.000E-01	3.000E-01	4.000E-01	4.800E-01	5.000E-01
C= 0.0	1.000E 00	1.000E 00	1.100E 00	1.200E 00	1.300E 00	2.000E 00	1.000E 02
C= 1.000E-01	1.000E 00	1.000E 00	1.200E 00	1.300E 00	1.400E 00	2.400E 00	1.200E 02
C= 2.000E-01	1.100E 00	1.100E 00	1.200E 00	1.400E 00	1.600E 00	3.000E 00	1.600E 02
C= 4.000E-01	1.300E 00	1.300E 00	1.400E 00	1.500E 00	1.800E 00	4.000E 00	1.800E 02
C= 6.000E-01	1.700E 00	1.700E 00	1.900E 00	2.200E 00	2.500E 00	5.000E 00	2.000E 02
C= 8.000E-01	2.000E 00	2.000E 00	2.500E 00	3.000E 00	5.000E 00	6.000E 00	2.500E 02
C= 1.000E 00	4.000E 00	4.000E 00	6.000E 00	8.000E 00	1.000E 01	1.500E 01	3.000E 02
C= 2.000E 00	1.000E 01	1.000E 01	1.500E 01	2.000E 01	3.000E 01	4.000E 01	3.500E 02
C= 1.000E 01	1.000E 02	1.000E 02	2.000E 02	3.000E 02	3.500E 02	4.000E 02	4.000E 02

TABLE 2: BETA A

	A= 0.0	1.000E-01	2.000E-01	3.000E-01	4.000E-01	4.800E-01	5.000E-01
C= 0.0	1.100E 00	1.100E 00	1.100E 00	1.200E 00	1.300E 00	2.000E 00	1.000E 02
C= 2.000E-01	1.100E 00	1.100E 00	1.200E 00	1.300E 00	1.400E 00	2.400E 00	1.200E 02
C= 4.000E-01	1.100E 00	1.100E 00	1.200E 00	1.400E 00	1.600E 00	3.000E 00	1.600E 02
C= 8.000E-01	1.300E 00	1.300E 00	1.400E 00	1.500E 00	1.800E 00	4.000E 00	1.800E 02
C= 1.200E 00	1.700E 00	1.700E 00	1.900E 00	2.200E 00	2.500E 00	5.000E 00	2.000E 02
C= 1.600E 00	2.000E 00	2.000E 00	2.500E 00	3.000E 00	5.000E 00	6.000E 00	2.500E 02
C= 2.000E 00	4.000E 00	4.000E 00	6.000E 00	8.000E 00	1.000E 01	1.500E 01	3.000E 02
C= 4.000E 00	1.000E 01	1.000E 01	1.500E 01	2.000E 01	3.000E 01	4.000E 01	3.500E 02
C= 2.000E 01	1.000E 02	1.000E 02	2.000E 02	3.000E 02	3.500E 02	4.000E 02	4.000E 02

MATERIAL INPUT DATA

MATERIAL TYPE	YIELD STRENGTH	GROWTH EQUATION	RETARDATION MODEL	CRITICAL STRESS INTENSITY (SURFACE)	THRESHOLD STRESS INTENSITY (SURFACE)	CRITICAL STRESS INTENSITY (DEPTH)	THRESHOLD STRESS INTENSITY (DEPTH)
1	1.900E 02	4	0	9.000E 01	6.000E 00	9.000E 01	6.000E 00

MATERIAL TYPE 1 TABLE 7

RE= 0.0 3.000E-01 5.000E-01 1.000E 00

DKE= 6.000E 00	1.000E-13	3.000E-13	4.000E-13	4.000E-13
DKE= 8.000E 00	1.000E-09	3.000E-09	4.000E-09	4.000E-09
DKE= 1.000E 01	1.000E-08	3.000E-08	4.000E-08	4.000E-08
DKE= 1.200E 01	1.000E-07	3.000E-07	4.000E-07	4.000E-07
DKE= 1.600E 01	2.400E-06	7.200E-06	1.000E-05	1.000E-05
DKE= 3.000E 01	9.000E-06	2.700E-05	4.000E-05	4.000E-05
DKE= 8.400E 01	5.000E-05	1.500E-04	2.000E-04	2.000E-04
DKE= 9.000E 01	1.000E-02	3.000E-02	4.000E-02	4.000E-02

MATERIAL TYPE 1 TABLE 8

RE=	0.0	3.000E-01	5.000E-01	1.000E 00
DKE= 6.000E 00	1.000E-13	3.000E-13	4.000E-13	4.000E-13
DKE= 8.000E 00	1.000E-09	3.000E-09	4.000E-09	4.000E-09
DKE= 1.000E 01	1.000E-08	3.000E-08	4.000E-08	4.000E-08
DKE= 1.200E 01	1.000E-07	3.000E-07	4.000E-07	4.000E-07
DKE= 1.600E 01	2.400E-06	7.200E-06	1.000E-05	1.000E-05
DKE= 3.000E 01	9.000E-06	2.700E-05	4.000E-05	4.000E-05
DKE= 8.400E 01	5.000E-05	1.500E-04	2.000E-04	2.000E-04
DKE= 9.000E 01	1.000E-02	3.000E-02	4.000E-02	4.000E-02

RUN 2 TABULAR INPUT EXAMPLES

CRACK IS A PART THRU CRACK

BLOCK	STEP	CYCLES	HALF SURFACE CRACK LENGTH (IN)	CRACK DEPTH (IN)	KMAX-SURFACE (KSI ROOT-IN)	KMAX-DEPTH (KSI ROOT-IN)	SURFACE GROWTH RATE (IN/CYCLE)	DEPTH GROWTH RATE (IN/CYCLE)
1	1	0.0	7.500E-02	5.000E-02	4.768E 01	5.245E 01	1.947E-05	2.282E-05
1	1	2.500E 01	7.549E-02	5.057E-02	4.792E 01	5.271E 01	1.963E-05	2.301E-05
10	1	0.0	7.955E-02	5.534E-02	5.016E 01	5.517E 01	2.118E-05	2.483E-05
10	1	2.500E 01	8.008E-02	5.596E-02	5.041E 01	5.545E 01	2.136E-05	2.504E-05
20	1	0.0	8.508E-02	6.182E-02	5.301E 01	5.832E 01	2.323E-05	2.723E-05
70	1	2.500E 01	8.566E-02	6.250E-02	5.328E 01	5.861E 01	2.342E-05	2.745E-05
30	1	0.0	9.114E-02	6.891E-02	5.597E 01	6.157E 01	2.543E-05	2.981E-05
30	1	2.500E 01	9.177E-02	6.966E-02	5.625E 01	6.188E 01	2.564E-05	3.005E-05
40	1	0.0	9.776E-02	7.667E-02	5.904E 01	6.495E 01	2.779E-05	3.258E-05
40	1	2.500E 01	9.846E-02	7.749E-02	5.934E 01	6.527E 01	2.803E-05	3.285E-05
50	1	0.0	1.050E-01	8.515E-02	6.253E 01	6.844E 01	3.058E-05	3.555E-05
50	1	2.500E 01	1.058E-01	8.604E-02	6.289E 01	6.878E 01	3.088E-05	3.584E-05
60	1	0.0	1.130E-01	9.439E-02	6.636E 01	7.206E 01	3.377E-05	3.873E-05
60	1	2.500E 01	1.139E-01	9.536E-02	6.675E 01	7.242E 01	3.409E-05	3.905E-05
70	1	0.0	1.219E-01	1.045E-01	7.103E 01	7.602E 01	3.782E-05	4.234E-05
70	1	2.500E 01	1.228E-01	1.055E-01	7.158E 01	7.644E 01	3.830E-05	4.273E-05
80	1	0.0	1.319E-01	1.155E-01	7.673E 01	8.048E 01	4.301E-05	4.656E-05
80	1	2.500E 01	1.330E-01	1.167E-01	7.733E 01	8.095E 01	4.356E-05	4.701E-05
90	1	0.0	1.439E-01	1.372E-01	8.713E 01	6.904E 01	8.275E-04	4.377E-03

LIMIT LOAD FRACTURE OCCURS IN THE 24 BLOCK 1 STEP AFTER 2.287E 01 CYCLES

CRITICAL K AT DEPTH HAS BEEN EXCEEDED IN THE 90 BLOCK AND THE 1 STEP AFTER 5.148E-01 CYCLES

APPENDIX C

STRESS INTENSITY FACTORS

Through Cracks*

Center crack

$$K_c = \sigma_g \sqrt{\pi c \sec \frac{\pi c}{W}} \qquad \text{(Ref. C-1)}$$

Compact specimen, ASTM E399-74,

$$K_c = \frac{P}{th\ W}\left[29.6\ (\tfrac{c}{W})^{1/2} - 185.5\ (\tfrac{c}{W})^{3/2} + 655.7\ (\tfrac{c}{W})^{5/2} - 1017.0\ (\tfrac{c}{W})^{7/2} + 6.38.9\ (\tfrac{c}{W})^{7/2}\right] \qquad \text{(Ref. C-2)}$$

Single through crack at hole.

$$K_c = \sigma_g\ F_B\ F_w \sqrt{\pi c}$$

$$F_b = e^{(1.2133 - 2.205\ s + .6451\ S^2)}$$

$$s = c/(Rad + c)$$

$$F_w = \sqrt{\sec\ (\pi\ \frac{c+2\ Rad}{2\ \ (W-c)})}$$

F_b is an equation which fits Bowie's (Ref.C-3) numerical data for the effect of the hole. F_w is a modification of Feddersen's (Ref C-1) equation to account for the affect of finite width. The distance (W-c) is twice the distance from the closest edge to the midpoint of the hole and crack length. The effective half crack length in F_w is $(\frac{c+2\ Rad}{2})$.

* See Figure 3 for geometry definitions.

Double through crack at hole.

$$K_c = \sigma_g \; F_b \; F_w \; \sqrt{\pi c}$$

$$F_b = e^{(1.2133-2.086+.8727 \; S^2)}$$

$$S = D/(Rad+C)$$

$$F_w = \sqrt{\sec \frac{\pi(c+Rad)}{W}}$$

F_b is an equation which fits Bowie's (Ref.C-3) numerical data for the effect of the hole. F_w is a modification to Feddersen's (Ref. C-1) equation to account for the affect of finite width. (c+Rad) is used as an equivalent half crack length in F_w .

General tabular description

$$K_c = P \; F(c) \; \sqrt{\pi c}$$

F (c) is tabular input data.

P is applied load compatible with F(c)

Since numerical data may be generated by using a number of solutions (e.g., effect of hole and effect of width), the program has the capability of combining a number of tables to generate F(c). As many as three tables F1(c), F2(c), F3(c) may be input and F(c) is set equal to the interpolated value of

$$F(c) = F1(c)xF2(c)xF3(c)$$

The format for the stress intensity factor table is:

C 2

F1		F2		F3	
c(1,1)	F(1,1)	c(2,1)	F(2,1)	c(3,1)	F(3,1)
c(1,2)	F(1,2)	c(2,2)	F(2,2)	c(3,2)	F(3,3)
.	.	.	.	.	.
.	.	.	.	.	.
.	.	.	.	.	.
$c(1,\ell_1)$	$F(1,\ell_1)$	$c(2,\ell_2)$	$F(2,\ell_2)$	$c(3,\ell_3)$	$F(3,\ell_3)$

If only one table is read in, F2≡F3≡1. ℓ_1 and ℓ_2 and ℓ_3 must be ≤ 25.

Pin loaded lug - two through cracks

$$K_c = \left[\frac{P}{2th}\ \frac{1.05}{\sqrt{\pi Z}} \times \phi_P + \frac{\sqrt{\pi c}}{W}\ \phi_\sigma\right]$$

$$\phi_\sigma = \tfrac{1}{2}\left[\phi_{\sigma},c + \phi_{\sigma},_5\right] \times F_B$$

$$F_B = e^{(1.2133-2.086 \times 5 + .8727 \times S^2)}$$

$$S = c/Rad + C$$

$$\phi_{\sigma,s} = \sqrt{\sec\frac{\pi Z}{W}}\ f3(Z/H) \qquad \text{(see Table C1)}$$

$$\phi_{\sigma,c} = \frac{1}{\sqrt{1-\frac{2Z}{W}}} \times f2(Z/b \qquad \text{(see Table C1)}$$

$$\phi_p = \tfrac{1}{2}\left[\phi_{p,c} + \phi_{p,w}\ \phi_{p,H}\right]$$

$$\phi_{p,h} = 1-.08\left(\frac{2Z}{H}\right) + 2.69\left(\frac{2Z}{H} - .91\left(\frac{2Z}{H}\right)^3\right.$$

$$\phi_{P,w} = \frac{1}{\sqrt{1-\frac{2Z}{W}}}\ 1-.5\left(\frac{2Z}{W}\right) + .957\left(\frac{2Z}{W}\right)^2 - .16\left(\frac{2Z}{W}\right)^3$$

$$\phi_{P,c} = \frac{1}{\sqrt{1-\frac{2Z}{w}}}\ f1(Z/b) \qquad \text{(see Table C1)}$$

$$Z = Rad + C$$

$\frac{Z}{b'}$, or $\frac{Z}{b}$(b=w/2)	f1	$\frac{Z}{b'}$, or $\frac{Z}{b}$ (b=w/2)	f2	2Z/H	f3
0.00	1.00	0.00	1.00	1.00	0.00
.06	.98	.06	.98	1.0542	.1666
.12	1,	.13	.96	1.0666	.20
.19	1.06	.18	.955	1.075	.25
.34	1.24	.20	.95	1.0916	.333
.40	1.3	.26	.95	1.25	.50
.48	1.36	.32	.955	1.333	.5714
.54	1.38	.62	1.0	1.4166	.6315
.60	1.395	.70	1.01	1.625	.80
.72	1.395	.76	1.01	1.75	.8888
.80	1.38	.80	1.0	2.00	1.0909
.86	1.36	.86	.98	2.24	1.2632
.96	1.32	.90	.96	2.72	1.60
1.0	1.297	.94	.92	3.64	2.1819
		.97	.88	4.416	2.6666
		1.0	.826	8.00	4.8007

TABLE CI- Functions for Pin Loaded Lug

The stress intensity factor is composed of two basic parts, that due to the uniform stress (P/Wth) and that due to the pin load P. The subscript σ in the equations, applies to the former and the subscript P refers to the latter.

The 1.05 factor on the pin load portion is there to account for the extra driving force due to the presence of Mode II stress intensity factors as well as Mode I.

The pin load and uniform stress portions of the expression are composed of factors accounting for the effect of the hole (subscripted by B), the effect of the circular end (subscripted by C) for the effect of the straight sides (subscripted by S). The latter contains effects of the finite width (subscripted by w), and height subscripted by H.

The expression for the effect of the hole has been described above. $\phi_{\sigma,s}$ combines Feddersen's width effect and a tabular description of the effect of the height taken from the data of Fichter (Ref.C-4). $\phi_{\sigma,c}$ is a tabular description of pg. 11.6 of (Ref. C-5) . $\phi_{p,c}$ is a tabular description of pg. 11.9 of Ref. (C-5) $\phi_{p,H}$ is taken from Ref.(C-5) and $\phi_{p,w}$ is the width effect presented by Tada (Ref. C-7). The effective half crack length used in Rad + C.

<u>Pin loaded Lug - single through crack</u>

$$K_c = \frac{P}{2th}\left[\frac{1 + \frac{1}{9}\left(\frac{z+e}{z-e}\right)\sqrt{\frac{z-e}{z+e}}}{\sqrt{\pi z}}\phi_p + \frac{\sqrt{\pi C}}{W}\phi_\sigma\right]$$

$$\phi_\sigma = \tfrac{1}{2}\left(\phi_{\sigma,c} + \phi_{\sigma,s}\right) F_B$$

$$F_B = e^{(1.2133-2.225\ S^2 + .6451\ S^2)}$$

$$S = c/Rad + C$$

$$\phi_{\sigma,s} = \sqrt{\sec\frac{\pi z}{2B'}}\ F3\ \ (Z/H)$$

$$b' = \frac{W}{2} - \frac{c}{2}$$

$$\phi_{\sigma,c} = \frac{1}{\sqrt{1-\frac{z}{B'}}}\ F2\ (Z/b')$$

$$\phi_p = \tfrac{1}{2}\left[\phi_{p,c} + \phi_{p,H}\ \ \phi_{p,w}\right]$$

$$\phi_{p,h} = 1-.08\left(\frac{2Z}{H}\right)+2.69\left(\frac{2Z}{H}\right)^2-.99\left(\frac{2Z}{H}\right)^3$$

$$\phi_{p,h} = \frac{1}{1-\frac{Z}{b'}}\left[1-.5\left(\frac{Z}{b'}\right)+.957\left(\frac{Z}{b'}\right)^2-.16\left(\frac{Z}{b'}\right)^3\right]$$

$$\phi_{p,c} = \frac{1}{1-\frac{Z}{b'}}\ F1(Z/B')$$

$$Z = \frac{C+2Rad}{2}$$

$$e = C/2$$

The above exceptions are generated in a similar manner to the double crack case except that:

a) The single crack expression for the hole effect is used.

b) The effective half crack length is (C+2Rad)/2.

c) The effective half width is taken to be $\frac{w}{2} - \frac{c}{2}$

Double crack at double notch

$$K_c = \phi_g\sqrt{\pi c}\ f4\ (S, height/b)F_w \quad \text{(See Table C-2)}$$

$$S = c/b+c$$

$$F_w = \left[\frac{1+.122\left(\cos\pi\left(\frac{b+c}{w}\right)\right)^4}{1.122}\right]\sqrt{\frac{w}{\pi(b+c)}\tan\frac{\pi(b+c)}{w}}$$

Where F_w is a modification of the double edge cracked tensile formula given by Tada (pg. 2.7) (Ref.C-5).

f4 (S, height/b)

Height/b	S .01	.05	.1	.2	.3	.4	.6	.8	1
0	11.22	5.02	3.55	2.51	2.05	1.77	1.45	1.25	1.122
.25	9.5	5.02	3.55	2.51	2.05	1.77	1.45	1.25	1.122
.333	8.4	5.02	3.55	2.51	2.05	1.77	1.45	1.25	1.122
.5	5.8	4.1	3.5	2.51	2.05	1.77	1.45	1.25	1.122
1	3.5	3	2.8	2.4	2.0	1.77	1.45	1.25	1.122
2	2.3	2.2	2.2	2	1.8	1.7	1.35	1.25	1.122
4	1.5	1.45	1.4	1.35	1.3	1.25	1.2	1.18	1.122
∞	1.122	1.122	1.122	1.122	1.122	1.122	1.122	1.122	1.122

TABLE C-2

Function For Cracks at Notches

F4 (S, height/b) is a table constructed from the curves presented by Tada (pg. 19.13) for a crack emanating from an edge notch is a semi-infinite sheet.

Single crack at single edge notch.

$$K_c = \phi_g \sqrt{\pi C}\ f4(S,\ height/b)\ F_w$$

$$F_w = \left[\frac{.752+2.02\left(\frac{b+c}{W}\right)+.37\left(1-\sin\frac{\pi(b+c)}{2w}\right)}{1.122\ \cos\frac{\pi(b+c)}{2W}}\right]\sqrt{\frac{2W}{\pi(b+c)}\tan\frac{\pi(b+c)}{2W}}$$

$$S = c/b+c$$

Where F_w is a modification of the single edge cracked tensile formula given by Tada (pg. 2.11, Ref. C-5).

Cracks coming out of shoulder

$$K_c = \phi_g \sqrt{\pi C}\ f4\ (S,g)\ F_w \qquad \text{(See Table C-2)}$$

$$F_w = \frac{\left[1+.122\left(\cos\left(\frac{\pi(b'+C)}{W}\right)\right)^4\right]\sqrt{\frac{w}{\pi(b'+c)}\tan\frac{\pi(b'+c)}{W}}}{1.122}$$

$$g = f5\left(\frac{rad}{d},\ w/d\right) \qquad \text{(See Table C-3)}$$

$$b' = (w-d)/z$$

$$S = c/c+b'$$

The above solution for the stress intensity factor is based on using the solution for the case of cracks coming out of a doubly

$f5\ (\frac{Rad}{d}\ w/d)$

rad/d \ w/d	1.01	1.02	1.05	1.07	1.1	1.15	1.2	1.3	1.5	2	3
.02	1.75	1.2	.95	.87	.82	.75	.55	.44	3.6	2.6	.18
.04	3	1.75	1.38	1.25	1.12	1.15	1.15	1.1	1.35	1.7	3
.06	4	2.8	1.85	1.63	1.5	1.5	1.45	1.42	2	5	5
.08	4.5	3.5	2	2	1.87	2	1.85	1.84	3.5	5	7
.1	5	4	3	2.7	2.3	2.6	2.25	3.3	4.4	6	8
.12	6	4.3	3.3	3.1	3	4.4	5	5	5	6.5	9
.14	7	4.7	3.6	3.5	3.5	5	6.3	6	6	7	10
.18	8	5	4	4	4	6.5	7.5	7.5	8	9	11
.22	8.5	6	4.5	4.4	4.5	7.5	8.5	8.5	9	10	12
.26	9	6.5	4.75	4.7	4.75	8.5	8.5	9.5	10	11	12
.3	9	7	5	5	5	9.5	9.5	10	11	12	12

TABLE C-3

notched plate, whose notch dimensions are chosen such that the notch depth is equal to (W-d)/2 and the notch height is such that the stress concentration factor in the shoulder is the same as that at the notch. The table used to generate "g" is developed using the stress concentrations for a shoulder fillet (Ref. (C-6) and the stress concentration factor for a notch in a finite width plate.

Part Through Cracks

Basic Part through crack solution.

$$B = \text{minimum } (a,c)$$

$$K_c = \sigma_g \sqrt{\pi B}\ F\ (a/c,2) \qquad \text{(See Table C-4)}$$

$$K_a = \sigma_g \sqrt{\pi B}\ F\ (a/c,1)$$

Where the function F is given in Table C-4 and accounts for the effect of crack shape.

The stress intensity equations for part through cracks in varying geometries were constructed using the above relations, the through crack equations for each geometry and the following rules.

1) The effect of the back surface on the stress intensity factor at the crack depth is considered for the center part through crack. This factor is

TABLE C-4

Part Through Crack Shape Factors

a/c	F(a/c,1)	F(a/c,2)
0	1.122	0
.04	1.11	0.17
.07	1.10	0.27
.12	1.08	0.37
.15	1.07	0.42
.21	1.04	0.5
.34	0.97	0.6
.58	0.84	0.71
.72	0.77	0.74
.775	0.75	0.75
.86	0.75	0.76
1.0	0.655	0.775
1.25	0.65	0.82
1.49	.63	0.86
1.785	0.61	0.9
2.325	0.57	0.96
3.45	0.5	0.975
5.0	0.43	0.99
6.66	0.38	0.998
10.0	0.31	1.0
25.0	0.17	1.0
50.0	0.1	1.0
100.0	0.15	1.0
10000.	0	1.0

$$M_{back} = 1 + \frac{1}{0.502}\left[0.089\left(\frac{a}{t}\right) - 0.2315\left(\frac{a}{t}\right)^2 - 0.3873\left(\frac{a}{t}\right)^3 + 5.28\left(\frac{a}{t}\right)^4 - 9.11\left(\frac{a}{t}\right)^5 + 5.233\left(\frac{a}{t}\right)^6\right]$$
$$\times\left[1.109 - 9.142\left(\frac{a}{2c}\right) + 41.56\left(\frac{a}{2c}\right)^2 - 86.55\left(\frac{a}{2c}\right)^3 + 65.5\left(\frac{a}{2c}\right)^4\right] \quad \text{(Ref. C-7)}$$

For cracks coming out of holes, notches and radii, there is strong evidence (Ref.C-8) that the effect of the back surface effect is minimal and therefore it has not been included.

2) In using those parts of the through crack equation that deal with the effect of a local stress concentration (such as the Bowie correction factor F_B) the effect of the stress concentration at both the surface and depth of the crack is evaluated by using the leading crack position. The use of other positions (and therefore higher factors) has been shown to be an over estimate of the effect.

3) In accounting for the affects of finite widths, the actual position of the portion of the crack front for which the stress intensity is being evaluated is used in calculating the effect of the finite width.

4) For an embedded flow, care is taken that the free edge of the notch or hole is not accounted for twice (i.e., through the basic ptc equation and through the through crack equations)

thus, it is necessary to factor out 1.122 from the combination of ptc and through crack equations.

5) For the embedded flaws, the roles of F (a/c,2) and F (a/c,1) with respect to the stress intensity at the depth and surface are switched.

6) "a" is always taken to be in the thickness direction. "c" is always perpendicular to the thickness directions and identical to the through crack definition of "c".

Transition Crack

$$K_c = K_c\left(\frac{C+C_b}{2}\right)$$

where

$K_c\left(\frac{C+C_b}{2}\right)$ is the appropriate through crack equation with "c" replaced by $\left(\frac{C+C_b}{2}\right)$

$$K_a = \sqrt{\left[(CB/C)\Big/\ 1-(1-(\frac{CB}{C})^2)^{\frac{1}{2}}\right]}$$

K_c is the stress intensity for the leading portion of the crack front and K_a is the stress intensity for the trailing portion. The above equation is an approximate expression developed by R.M. Ehret (Ref.C-9) which predicts observed crack growth behavior.

```
      COMMON X(12,25),Y(12,25),TABLE(12,25,25),FIXED,KCPRF,KAPPF,
     1 PROOFX,NKTMX,NOX(12),NOY(12),NTAB(10),IPLOT,IFAIL,CUMSUM,PCYC(2)
      COMMON A,AP(2),ALIM,AOL(2),C,CB,CLIM,CR(2,10,10),CO,CUME,
     1 CUMELM,C1B1,D(2,10,10),DK,DKE,DXDX,FA,FC,H,INC,KCL,KC1,KOL,
     2 KOA,KOC,KCRA,KCRC,KMAX,OA,OC,PI,R,RAD,RE,RYOL(2),ROL(2),
     3 SIG,SIGLM,SIGY,SIGYS(10),SMIN(422),SMAX(422),TH,
     4 UNIT(422),W,DCTMP,DFLTMP,DXTMP,
     5 ALOWN,BLOCK,FLAG1,I,ICD(2),ICK(2),ICR(2),IBLOCK,IFIRST,IPRN(4),
     6 ISTEP,ITRANS,J,KTYPE(2),NC,NEQ(10),NR,NRET(10),TYPE,TITL
      DIMENSION THICK(10),PCTLF(10),A1(10),CI(10)
      DIMENSION FL(4,3),KTYPO(2),KTN(3,2)
      DIMENSION HMIN(422),HMAX(422)
      INTEGER ALOWN,BLOCK,FLAG1,TYPE(422),ONSTEP,TITL(20)
      INTEGER HNSTEP
      INTEGER PD1(2),PD2(4),PD3(4)
      REAL KCL,KC1,KOL,KOA(10),KOC(10),KCRA(10),KCRC(10),KMAX,INC
      REAL LIFE(10),KCPRF,KAPRF
      DATA PD1 /4HR A ,4HR C /
      DATA PD2 /4HA/C ,4HFIXF,4HC   ,4HA   /
      DATA PD3 /4H    ,4HD   ,4H    ,4H    /
      DATA FL /4H DEP,4HSURF,4HBREA,4H TRA,4HTH  ,4HACF ,4HKTHR,4HNSIT,
     1        4H    ,4H    ,4HOUGH,4HION /
      DATA KTN /4H  PT,4HTRAN,4H   T,4HC - ,4HS - ,4HC - /
      DATA KEND /4H END/
C
C     INITIALIZATION FOR ALL RUNS
C
      DO 10 I=1,2
      DO 10 J=1,10
      NTAB(J)=0
      DO 10 K=1,10
      D(I,J,K)=0
   10 CR(I,J,K)=0
      PI=3.1415927
      DCTMP=0.
      DFLTMP=0.
      DXTMP=0.
      ONSTEP=-1
      NR=0
C
C     READ TITLE & CONTROL INFO FOR ALL RUNS
C
C     NRUNS = # RUNS TO BE MADE       NBLOCK= MAX BLOCKS PER RUN
C     MBLOCK= PRINT FREQ (BLOCKS)     MSTEP = PRINT FREQ (STEPS)
C
      READ (5,5001) (TITL(I), I=1,20)
      READ (5,5002) NRUNS,NBLOCK,MBLOCK,MSTEP
      IF (MBLOCK) 30,20,30
   20 MBLOCK=NBLOCK+1
C
C     CENTER TITLE
C
   30 DO 32 I=1,14
      IF (TITL(I).EQ.PD3(1)) GO TO 34
   32 CONTINUE
      GO TO 100
   34 IF (I.GE.13) GO TO 100
      II=(13-I)/2 + 1
      K=14-I-II
      I1=14-II
```

```
      I2=I1-I+1
      DO 36 L1=I2,I1
      L=I1+I2-L1
      J=L-K
      TITL(L)=TITL(J)
      TITL(J)=PD3(1)
   36 CONTINUE
C
C     READ CONTROL INFO FOR INDIVIDUAL RUN
C
C     CSTRS = STRESS MULTIPLIER      NSUP  = 0 TO SUPPRESS RETARDATION
C     NLOAD = 1 FOR LOAD INPUT       NGEOM = 1 FOR GEOMETRY INPUT
C     NMAT == 1 FOR MATERIAL INPUT   NPROOF= 1 FOR PROOF INPUT
C     ITERTP= ITERATION TYPE (OPT)   ITER  = # OF ITERATIONS
C     PIT   = CONVERGENCE PARAM      BLIFE = DESIRED LIFE IN BLOCKS
C     PLOT  > 0 TO GENERATE PLOT     PCYCLES(1)=PLOT FREQ (CYCLES) (OPT)
C
  100 READ (5,5003) CSTRS,NSUP,NLOAD,NGEOM,NMAT,ITERTP,ITER,PIT,BLIFE,
     1 NPROOF,IPLOT,PCYC(1)
      IF (ITER.LT.1) GO TO 110
      IF (ITERTP.EQ.0) GO TO 4020
      IF (ITERTP.GT.4) GO TO 4020
  110 DO 120 K=1,10
  120 NRET(K)=NSUP*NRET(K)
      ITCNT=0
      IF (IPLOT.EQ.0) GO TO 130
      IPLOT=1
      IF (PCYC(1).EQ.0) GO TO 130
      IPLOT=2
  130 IF (ITER-10) 800,800,140
  140 ITER=10
C
C     READ LOAD INPUT
C
  800 IF (NLOAD-1) 910,810,910
  810 READ (5,5004) NSTEP,IR,SIGLM
      IF (MSTEP-(ONSTEP+1)) 820,830,820
  820 IF (MSTEP)  840,830,840
  830 MSTEP=NSTEP+1
  840 DO 850  I=1,NSTEP
  850 READ (5,5005) SMAX(I),SMIN(I),UNIT(I),TYPE(I)
      IF (IR-1) 880,860,880
  860 DO 870 I=1,NSTEP
  870 SMIN(I)=SMIN(I)*SMAX(I)
  880 IF (CSTRS) 890,910,890
  890 SIGLM = CSTRS*SIGLM
      DO 900 I=1,NSTEP
      SMIN(I)=CSTRS*SMIN(I)
  900 SMAX(I)=CSTRS*SMAX(I)
C
C     READ GEOMETRY INPUT
C
  910 IF (NGEOM-1) 1100,920,1100
  920 READ (5,5004) KTYPO
      READ (5,5006) W,TH,CO,AO,H,RAD
      OTH=TH
      OAO=AO
      OCO=CO
      IF (KTYPO(1).LT.1) GO TO 4030
      IF (KTYPO(1).GT.3) GO TO 4030
```

```
      IF (KTYPO(2).LT.1) GO TO 4060
      IF (KTYPO(2).GT.17) GO TO 4060
      IF (KTYPO(2).EQ.7) GO TO 940
      IF (KTYPO(2).EQ.16) GO TO 930
      IF (KTYPO(2).EQ.17) GO TO 930
      GO TO 1100
  930 C1B1 = FUNT5(RAD/H,W/H)
      GO TO 1100
C
C     READ X,Y,TABLE ARRAYS(1-6) FOR INTERPOLATION
C
C     NKTMX = ONE HALF # ARRAY ELEMENTS
C
  940 READ(5,5002) NKTMX
      IF (NKTMX.LT.1) GO TO 980
      IF (NKTMX.LT.4) GO TO 990
  980 WRITE(6,6024) NKTMX
      STOP
  990 NTABLE=6
      N1=1
      N2=2*NKTMX
      DO 1090 NT=N1,N2
      IF (AO.NE.0.) GO TO 1000
      I=MOD(NT,2)
      IF (I.NE.0) GO TO 1000
      X(NT,1)=0.
      Y(NT,1)=0.
      NOX(NT)=1
      NOY(NT)=1
      TABLE(NT,1,1) = 0.
      GO TO 1090
 1000 READ(5,5009) X(NT,I),LEND
      I=1
      IF (LEND.EQ.KEND) GO TO 1030
      DO 1020 I=2,25
      READ(5,5009) X(NT,I),LEND
      IF (X(NT,I).LE.X(NT,I-1)) GO TO 4000
 1020 IF (LEND.EQ.KEND) GO TO 1030
      GO TO 4010
 1030 NOX(NT)=I
      IF (AO.NE.0.) GO TO 1040
      Y(NT,1)=0.
      Y(NT,2)=1.
      I=2
      GO TO 1070
 1040 READ(5,5009) Y(NT,I),LEND
      I=1
      IF (LEND.EQ.KEND) GO TO 1070
      DO 1060 I=2,25
      READ(5,5009) Y(NT,I),LEND
      IF (Y(NT,I).LE.Y(NT,I-1)) GO TO 4000
 1060 IF (LEND.EQ.KEND) GO TO 1070
      GO TO 4010
 1070 NOY(NT)=I
      I1=NOX(NT)
      I2=NOY(NT)
      DO 1080 I=1,I1
      READ(5,5008) (TABLE(NT,I,I3), I3=1,I2)
      IF (AO.NE.0.) GO TO 1080
      TABLE(NT,I,2) = TABLE(NT,I,1)
```

```
 1080 CONTINUE
 1090 CONTINUE
C
C     READ MATERIAL INPUT
C
 1100 IF (NMAT-1) 1490,1110,1490
 1110 READ (5,5002) NJ
      NTABLE=6
C
      DO 1450 J=1,NJ
C
      NTAB(J)=0
      READ (5,5007) SIGYS(J),NEQ(J),NRET(J),NDUP,
     1 KCRC(J),KOC(J),KCRA(J),KOA(J)
      NRET(J)=NSUP*NRET(J)
      IF (NEQ(J).NE.4) GO TO 1240
C
C     READ X,Y,TABLE ARRAYS(7-12) FOR NEQ(J)=4 & J<4
C
      NTABLE=NTABLE+1
      IF (NTABLE.GT.12) GO TO 1340
      NTAB(J)=NTABLE
      IF (J.GT.3) GO TO 1240
      N1=NTAB(J)
      N2=N1+1
      DO 1230 NT=N1,N2
      IF (NDUP.EQ.1) GO TO 1140
      I=MOD(NT,2)
      IF (I.NE.0) GO TO 1140
      I=NT-1
      NOX(NT)=NOX(I)
      NOY(NT)=NOY(I)
      I1=NOX(I)
      I2=NOY(I)
      DO 1120 I3=1,I2
 1120 Y(NT,I3)=Y(I,I3)
      DO 1130 I3=1,I1
      X(NT,I3)=X(I,I3)
      DO 1130 I4=1,I2
 1130 TABLE(NT,I3,I4)=TABLE(I,I3,I4)
      GO TO 1230
C
C     READ X ARRAY
C
 1140 READ(5,5009) X(NT,1),LEND
      I=1
      IF (LEND.EQ.KEND) GO TO 1170
      DO 1160 I=2,25
      READ(5,5009) X(NT,I),LEND
      IF (X(NT,I).LE.X(NT,I-1)) GO TO 4000
 1160 IF (LEND.EQ.KEND) GO TO 1170
      GO TO 4010
 1170 NOX(NT)=I
C
C     READ Y ARRAY
C
      READ(5,5009) Y(NT,1),LEND
      I=1
      IF (LEND.EQ.KEND) GO TO 1200
      DO 1190 I=2,25
```

```
      READ(5,5009) Y(NT,I),LEND
      IF (Y(NT,I).LE.Y(NT,I-1)) GO TO 4000
 1190 IF (LEND.EQ.KEND) GO TO 1200
      GO TO 4010
 1200 NOY(NT)=I
      I1=NOX(NT)
      I2=NOY(NT)
      DO 1210 I=1,I1
 1210 READ(5,5008) (TABLE(NT,I,I3), I3=1,I2)
      I3=NOY(NT)
      I2=I3+1
      NOY(NT)=I2
      Y(NT,I2)=1.
      DO 1220 I=1,I1
 1220 TABLE(NT,I,I2)=TABLE(NT,I,I3)
 1230 CONTINUE
      NTABLE=NTABLE+1
      GO TO 1340
C
C     READ D ARRAY FOR NEQ(J) NOT = 4
C
 1240 DO 1250 I=1,10
      D(1,I,J)=0
 1250 D(2,I,J)=0
      DO 1260 I=1,10
      READ (5,5009) D(1,I,J),LEND
 1260 IF (LEND.EQ.KEND) GO TO 1270
      GO TO 4070
 1270 IF (NDUP-1) 1280,1300,1280
 1280 DO 1290 I=1,10
 1290 D(2,I,J)=D(1,I,J)
      GO TO 1340
 1300 DO 1310 I=1,10
      READ (5,5009) D(2,I,J),LEND
 1310 IF (LEND.EQ.KEND) GO TO 1340
      GO TO 4070
 1340 IF (NRET(J)) 1350,1450,1350
 1350 DO 1360 I=1,10
      CR(1,I,J)=0
 1360 CR(2,I,J)=0
      DO 1370 I=1,10
      READ (5,5009) CR(1,I,J),LEND
 1370 IF (LEND.EQ.KEND) GO TO 1380
      GO TO 4070
 1380 IF (NDUP-1) 1390,1410,1390
 1390 DO 1400 I=1,10
 1400 CR(2,I,J)=CR(1,I,J)
      GO TO 1450
 1410 DO 1420 I=1,10
      READ (5,5009) CR(2,I,J),LEND
 1420 IF (LEND.EQ.KEND) GO TO 1450
      GO TO 4070
 1450 CONTINUE
C
C     READ PROOF INPUT DATA
C
 1490 IF (NPROOF.EQ.0) GO TO 1500
      READ(5,5010) FIXED,KCPRF,KAPRF,XLOW,XUP,PROOFX,IEND
C
C     INCREMENT RUN # & VERIFY COMPLETE INPUT
```

```
C
 1500 NR=NR+1
      IF (NR-1) 1510,1510,1530
 1510 I=NLOAD+NGEOM+NMAT
      IF (I-3) 4050,1520,4050
 1520 OCSTRS=CSTRS
      ONSTEP=NSTEP
      GO TO 1620
 1530 IF (NLOAD-1) 1540,1520,1540
 1540 IF (OCSTRS-CSTRS) 1550,1620,1550
 1550 IF (OCSTRS) 1580,1560,1580
 1560 DO 1570 I=1,ONSTEP
      SMIN(I)=SMIN(I)*CSTRS
 1570 SMAX(I)=SMAX(I)*CSTRS
      SIGLM = CSTRS*SIGLM
      OCSTRS=CSTRS
      GO TO 1620
 1580 DO 1590 I=1,ONSTEP
      SMIN(I)=SMIN(I)/OCSTRS
 1590 SMAX(I)=SMAX(I)/OCSTRS
      SIGLM = SIGLM/OCSTRS
      OCSTRS=CSTRS
      IF (CSTRS) 1600,1620,1600
 1600 DO 1610 I=1,ONSTEP
      SMIN(I)=SMIN(I)*CSTRS
 1610 SMAX(I)=SMAX(I)*CSTRS
      SIGLM = CSTRS*SIGLM
 1620 HNSTEP=NSTEP
      HSIGLM=SIGLM
      HCSTRS=CSTRS
      DO 1622 I=1,HNSTEP
      HMIN(I)=SMIN(I)
 1622 HMAX(I)=SMAX(I)
 1625 IF (IPLOT.NE.1) GO TO 1630
      K=NBLOCK/MBLOCK
      IF (K.EQ.0) GO TO 4040
      K=NSTEP/MSTEP
      IF (K.EQ.0) GO TO 4040
C
C     DISPLAY ALL INPUT FOR EACH ITERATION OF EACH RUN
C
 1630 WRITE(6,8002) NR,NRUNS,TITL
C
C     DISPLAY LOAD INPUT
C
      WRITE(6,8003) CSTRS,SIGLM
      BCYCLE=0.
      DO 1640 J1=1,NSTEP
      BCYCLE = BCYCLE + UNIT(J1)
 1640 WRITE(6,8004) J1,SMAX(J1),SMIN(J1),UNIT(J1),TYPE(J1)
C
C     DISPLAY GEOMETRY INPUT
C
      WRITE(6,8005) KTN(KTYPO(1),1),KTN(KTYPO(1),2),KTYPO(2),W,H,RAD,TH
      IF (KTYPO(1)-3) 1660,1650,1660
 1650 WRITE(6,8007) CO
      GO TO 1665
 1660 WRITE(6,8006) AO
      WRITE(6,8007) CO
 1665 IF (KTYPO(2).NE.7) GO TO 1750
```

```
      N1=2*NKTMX
      DO 1740 NT=1,N1
      I1=MOD(NT,2)
      IF (I1.EQ.0) GO TO 1670
      WRITE(6,8014) NT
      GO TO 1680
 1670 WRITE(6,8017) NT
 1680 CONTINUE
      I2=NOY(NT)
      I1=NOX(NT)
      J1=1
      J2=8
 1690 IF (J2-I2) 1710,1710,1700
 1700 J2=I2
 1710 WRITE(6,8015) (Y(NT,I3), I3=J1,J2)
      DO 1720 I=1,I1
 1720 WRITE(6,8016) X(NT,I),(TABLE(NT,I,I3), I3=J1,J2)
      IF (I2-J2) 1730,1740,1730
 1730 J1=J1+8
      J2=J2+8
      GO TO 1690
 1740 CONTINUE
C
C     DISPLAY MATERIAL INPUT
C
 1750 WRITE(6,8008)
      DO 1760 J1=1,NJ
      WRITE(6,8009) J1,SIGYS(J1),NEQ(J1),NRET(J1),KCRC(J1),KOC(J1),
     1 KCRA(J1),KOA(J1)
 1760 CONTINUE
C
C     DISPLAY D & CR ARRAYS IF ANY
C
      K=0
      DO 1840 J1=1,NJ
      IF (NEQ(J1).NE.4) GO TO 1770
      IF (J1.GT.3) GO TO 1770
      GO TO 1840
 1770 IF (K.GT.0) GO TO 1780
      K=K+1
      WRITE(6,8010)
 1780 DO 1830 J2=1,10
      IF (D(1,J2,J1)) 1820,1790,1820
 1790 IF (D(2,J2,J1)) 1820,1800,1820
 1800 IF (CR(1,J2,J1)) 1820,1810,1820
 1810 IF (CR(2,J2,J1)) 1820,1830,1820
 1820 WRITE(6,8011) J2,J1,D(1,J2,J1),D(2,J2,J1),
     1 CR(1,J2,J1),CR(2,J2,J1)
 1830 CONTINUE
 1840 CONTINUE
C
C     DISPLAY TABLES 7-12 IF ANY
C
      DO 1910 J=1,NJ
      IF (NEQ(J).NE.4) GO TO 1910
      IF (J.GT.3) GO TO 1910
      N1=NTAB(J)
      N2=N1+1
      DO 1900 NT=N1,N2
      WRITE(6,8019) J,NT
```

```
      I2=NOY(NT)
      I1=NOX(NT)
      J1=1
      J2=8
 1850 IF (J2-I2) 1870,1870,1860
 1860 J2=I2
 1870 WRITE(6,8020) (Y(NT,I3), I3=J1,J2)
      DO 1880 I=1,I1
 1880 WRITE(6,8021) X(NT,I),(TABLE(NT,I,I3), I3=J1,J2)
      IF (I2-J2) 1890,1900,1890
 1890 J1=J1+8
      J2=J2+8
      GO TO 1850
 1900 CONTINUE
 1910 CONTINUE
C
C     DISPLAY PROOF INPUT IF ANY
C
      IF (NPROOF) 1940,1940,1920
 1920 N1=NPROOF+1
      N1=MOD(N1,2) + 1
      IF (IEND.GT.0) GO TO 1930
      IEND=100
 1930 WRITE(6,8018) NPROOF,PD1(N1),XLOW,PROOFX,PD1(N1),XUP,KCPRF,
     1 PD2(NPROOF),PD3(NPROOF),FIXED,KAPRF,IEND
 1940 IF (ITER) 1960,1960,1950
 1950 K=ITCNT+1
      WRITE(6,8012) BLIFE,PIT,K,ITERTP
 1960 CONTINUE
C
C     INITIALIZATION FOR EACH RUN
C
      ICK(1)=0
      ICK(2)=20
      ICD(1)=0
      ICD(2)=20
      ICR(1)=0
      ICR(2)=20
      INC=.01
      ING=0
      BLOCK=1
      I=1
      ITRANS=0
      IPRN(1)=-1
      IPRN(2)=-1
      IPRN(3)=-1
      IPRN(4)=2*NSTEP
      FLAG1=0
      CUME=0
      KTYPE(1)=KTYPO(1)
      KTYPE(2)=KTYPO(2)
      PCYC(2)=PCYC(1)
      IFAIL=0
      CUMSUM=0.
      IF (NPROOF) 1980,1980,1970
 1970 CALL PROOF(A0,C0,XLOW,XUP,IEND,NPROOF)
 1980 CONTINUE
      C=C0
      A=A0
      DA=A
```

```
      OC=C
      AP(1)=C0
      AP(2)=A0
      RYOL(1)=0
      ALOWN=0
      RYOL(2)=0
      KOL=0
      KCL=0
      KC1=0
C
C     WRITE TITLE, #CYCLES/BLOCK, & FIRST DATA POINT IF PLOT WANTED
C
      IF (IPLOT.EQ.0) GO TO 2000
      WRITE(7,7010) (TITL(I1), I1=1,15),BCYCLE
      WRITE(7,7000) A,C,CUMSUM
C
C     BEGINNING OF EACH STEP, EACH BLOCK
C
 2000 IF (MOD(BLOCK,MBLOCK)) 2050,2010,2050
 2010 IF (MOD(I,MSTEP)) 2050,2020,2050
 2020 DO 2040 K=1,3
      IF (IPRN(K)-IPRN(4)) 2040,2030,2040
 2030 IPRN(K)=IPRN(K)-2
 2040 CONTINUE
 2050 IF (ITRANS-1) 2070,2060,2070
 2060 CALL TRANS
      GO TO 2100
 2070 KT=KTYPE(1)
      GO TO (2090,2060,2080), KT
 2080 CALL TCGROW
      GO TO 2100
 2090 CALL PTCGRW
C
C     HAS THE RUN ENDED?
C
 2100 MORE=0
      IF (ICR(1)+1) 2310,2310,2200
 2200 CUME = 0
      I=I+1
C
C     IS THIS THE LAST STEP OF THIS BLOCK?
C
      IF (I-NSTEP) 2000,2000,2210
 2210 BLOCK=BLOCK+1
      IF (KTYPE(1).GT.1) GO TO 2230
      IF (A-OA)2300,2230,2300
 2230 IF (C-OC) 2300,2240,2300
 2240 IF (DELTMP-1.E-8) 2250,2300,2300
 2250 IF (DXTMP-1.E-8) 2260,2300,2300
 2260 IF (ITRANS-1) 2270,2280,2270
 2270 IF (KTYPE(1).GT.1) GO TO 2290
 2280 IF (DCTMP-1.E-8) 2290,2300,2300
 2290 WRITE(6,6020)
      ING=1
      GO TO 2310
 2300 OA=A
      OC=C
      I=1
C
C     IS THIS THE LAST BLOCK OF THIS RUN?
```

```
C
      IF (BLOCK-NBLOCK) 2000,2000,2310
C
C     ARE THERE ITERATIONS?
C
 2310 IF (ITER) 3000,3000,2320
C
C     ITERATION CALCULATIONS
C
 2320 ITCNT=ITCNT+1
      THICK(ITCNT)=TH
      AI(ITCNT)=AO
      CI(ITCNT)=CO
      LIFE(ITCNT)=FLOAT(BLOCK-1)+FLOAT(I)/FLOAT(NSTEP)
      LIFE(ITCNT)=LIFE(ITCNT)-((UNIT(I)-CUME)/UNIT(I))/FLOAT(NSTEP)
      PCTLF(ITCNT)=LIFE(ITCNT)*100./BLIFE
      IF (LIFE(ITCNT).EQ.C.) GO TO 2435
      DIF=PCTLF(ITCNT)/100.
      IF (DIF-.99) 2340,2340,2330
 2330 IF (DIF-1.05) 2440,2340,2340
 2340 IF (ITCNT-ITER) 2350,2440,2440
 2350 MORE=1
      IF (ITERTP.GT.1) GO TO 2400
      DIF=(BLIFE/LIFE(ITCNT))**(1./PIT)
      TH=TH*DIF
      IF(CSTRS) 2380,2360,2380
 2360 CSTRS=1./DIF
      DO 2370 K=1,ONSTEP
      SMIN(K)=SMIN(K)*CSTRS
 2370 SMAX(K)=SMAX(K)*CSTRS
      SIGLM=SIGLM*CSTRS
      OCSTRS=CSTRS
      GO TO 3000
 2380 CSTRS=CSTRS/DIF
      DO 2390 K=1,ONSTEP
      SMIN(K)=SMIN(K)/OCSTRS*CSTRS
 2390 SMAX(K)=SMAX(K)/OCSTRS*CSTRS
      SIGLM=SIGLM/OCSTRS*CSTRS
      OCSTRS=CSTRS
      GO TO 3000
 2400 DIF=(LIFE(ITCNT)/BLIFE)**(2./(PIT-2.))
      GO TO (2350,2410,2420,2430), ITERTP
 2410 CO=CO*DIF
      GO TO 3000
 2420 AO=AO*DIF
      GO TO 3000
 2430 AOOVCO=AO/CO
      CO=CO*DIF
      AO=AOOVCO*CO
      GO TO 3000
 2435 WRITE(6,6160)
      MORE=0
 2440 WRITE(6,6021)
      DO 2450 K=1,ITCNT
 2450 WRITE(6,6022) THICK(K),AI(K),CI(K),LIFE(K),PCTLF(K)
      CSTRS=HCSTRS
      NSTEP=HNSTEP
      SIGLM=HSIGLM
      DO 2455 I=1,NSTEP
      SMIN(I)=HMIN(I)
```

```
 2455 SMAX(I)=HMAX(I)
      TH=OTH
      CO=OCO
      AO=OAO
      IF (ING-1) 3000,2460,3000
 2460 WRITE(6,8013)
C
C     WRITE FINAL DATA FOR PLOT IF ANY
C
 3000 IF (IPLOT.EQ.0) GO TO 3040
      WRITE(7,7000) A,C,CUMSUM
      WRITE(7,7020)
      IF (IFAIL.GT.2) GO TO 3015
      IF (IFAIL.GT.0) GO TO 3010
      WRITE(7,7030)
      GO TO 3020
 3010 WRITE(7,7040) FL(IFAIL,1),FL(IFAIL,2),BLOCK,I,CUME,CUMSUM
      GO TO 3020
 3015 WRITE(7,7070) (FL(IFAIL,I1), I1=1,3),BLOCK,I,CUME,CUMSUM
 3020 IF (ITER.EQ.0) GO TO 3030
      WRITE(7,7050) THICK(ITCNT),AI(ITCNT),CI(ITCNT)
      GO TO 3040
 3030 WRITE(7,7060)
C
C     IS THIS THE LAST RUN?
C
 3040 IF (MORE.EQ.1) GO TO 1625
      IF (NR-NRUNS) 3050,3990,3990
 3050 IF (ICR(1)+1) 3060,100,3060
 3060 IF(FLAG1) 100,100,3070
 3070 WRITE(6,6019) IBLOCK,ISTEP,CUMELM
      GO TO 100
 3990 STOP
 4000 WRITE(6,6100)
      STOP
 4010 WRITE(6,6110)
      STOP
 4020 WRITE(6,6120) ITERTP
      STOP
 4030 WRITE(6,6130) KTYPO(1)
      STOP
 4040 WRITE(6,6150)
      STOP
 4050 WRITE(6,6001)
      STOP
 4060 WRITE(6,6130) KTYPO(2)
      STOP
 4070 WRITE (6,6140)
      STOP
 5001 FORMAT(20A4)
 5002 FORMAT(I4,I6,2I4)
 5003 FORMAT(E10.0,6I4,2E10.0,2I4,E10.0)
 5004 FORMAT(2I4,E10.0)
 5005 FORMAT(3E10.0,I4)
 5006 FORMAT(6E10.0)
 5007 FORMAT(F10.0,3I4,4F10.0)
 5008 FORMAT(8E10.0)
 5009 FORMAT(E10.0,66X,A4)
 5010 FORMAT(6E10.0,I4)
 6001 FORMAT(34H1INCOMPLETE INPUT SET, JOB ABENDED)
```

```
6019 FORMAT(35HOLIMIT LOAD FRACTURE OCCURS IN THE ,I6,7H BLOCK ,
   1 I4,12H STEP AFTER ,1PE12.3,7H CYCLES)
6020 FORMAT(10HONO GROWTH )
6021 FORMAT(28H1             ITERATION RESULTS ,//49X,
   1 11HPERCENT  OF,/20H   THICKNESS        A,11X,1HC,9X,
   2 20HLIFE   REQUIRED LIFE,//)
6022 FORMAT(1P4E12.3,0PF9.2)
6024 FORMAT(1H0,18HNKTMX OUT OF RANGE)
6100 FORMAT(1H0,35HX OR Y INPUT NOT IN ASCENDING ORDER)
6110 FORMAT(1H0,19HMORE THAN 25 X OR Y)
6120 FORMAT(1H0,'INCORRECT VALUE FOR ITERTP = ',I4)
6130 FORMAT(1H0,'INCORRECT VALUE FOR KTYPE = ',I4)
6140 FORMAT(1H0,20HMORE THAN 10 D OR CR)
6150 FORMAT(1H0,
   1 55HPLOT REQUESTED BUT FREQUENCY OF DATA POINTS NOT DEFINED)
6160 FORMAT(1H0,23HCALCULATED LIFE IS ZERO,/1H ,
   1 27HITERATIONS CAN NOT PROCEED )
7000 FORMAT(4HDATA,1P3E12.3)
7010 FORMAT(4HTITL,4X,15A4,1PE12.3)
7020 FORMAT(4HHDRS)
7030 FORMAT(4HHDR1,/4HHDR2,/4HHDR3)
7040 FORMAT(4HHDR1,5X,14HCRITICAL K AT ,2A4,8HEXCEEDED,/4HHDR2,I6,
   1 6H BLOCK,I5,5H STEP,1PE10.3,6H CYCLE,/4HHDR3,8X,
   2 14HTOTAL CYCLES =,E10.3)
7050 FORMAT(4HHDR4,11X,11HTHICKNESS =,1PE10.3,/4HHDR5,18X,4HAO =,
   1 E10.3,/4HHDR6,18X,4HCO =,E10.3)
7060 FORMAT(4HHDR4,/4HHDR5,/4HHDR6)
7070 FORMAT(4HHDR1,3X,25HFRACTURE OCCURRED DURING ,3A4,/4HHDR2,I6,
   1 6H BLOCK,I5,5H STEP,1PE10.3,6H CYCLE,/4HHDR3,8X,
   2 14HTOTAL CYCLES =,E10.3)
8002 FORMAT(4H1RUN,I4,3H OF,I4,5H RUNS,10X,20A4,/16HOLOAD INPUT DATA)
8003 FORMAT(1H-,5X,15HSTRESS FACTOR   ,1PE12.3,/1H ,5X,
   115HLIMIT STRESS    ,E12.3,/1H0,5X,
   262HSTEP   MAX STRESS   MIN STRESS   UNITS(CYCLES)   MATERIAL TYPE,
   3//)
8004 FORMAT(1H ,4X,I4,2X,1PE12.3,E13.3,2X,E12.3,8X,I4)
8005 FORMAT(1H-,19HGEOMETRY INPUT DATA,/1H0,5X,20HCRACK TYPE          ,
   1 2A4,I4,/1H ,5X,20HWIDTH               ,1PE12.3,
   2/1H ,5X,20HADDITIONAL DIMENSION,E12.3,
   3/1H ,5X,20HRADIUS/NOTCH DEPTH  ,E12.3,
   4/1H ,5X,20HTHICKNESS           ,E12.3)
8006 FORMAT(1H ,5X,20HCRACK DEPTH         ,1PE12.3)
8007 FORMAT(1H ,5X,20HHALF CRACK LENGTH   ,1PE12.3)
8008 FORMAT(1H-,19HMATERIAL INPUT DATA,/1H0,58X,8HCRITICAL,10X,
   1 9HTHRESHOLD,9X,8HCRITICAL,10X,9HTHRESHOLD,/1H ,5X,
   256HMATERIAL      YIELD        GROWTH     RETARDATION  STRESS ,
   363HINTENSITY  STRESS INTENSITY  STRESS INTENSITY  STRESS INTENSITY
   4,/1H ,7X,42HTYPE        STRENGTH       EQUATION        MODEL,9X,
   59H(SURFACE),9X,9H(SURFACE),10X,7H(DEPTH),11X,7H(DEPTH),/)
8009 FORMAT(1H ,6X,I4,4X,1PE12.3,5X,I4,8X,I4,8X,E12.3,3(6X,E12.3))
8010 FORMAT(1H0,21X,14H--------------,18HEQUATION CONSTANTS,
   114H--------------,/1H ,37H CONSTANT  MATERIAL     CRACK GROWTH ,
   228HRATE        RETARDATION MODEL,/1H ,17H  NUMBER       TYPE,6X,
   342HSURFACE        DEPTH        SURFACE        DEPTH)
8011 FORMAT(1H ,2X,I4,6X,I4,3X,1P4E12.3)
8012 FORMAT(1H-,20HITERATION PARAMETERS,/1H0,5X,
   1 20HDESIGN LIFE         ,1PE12.3,/1H ,5X,
   2 20HCONVERGENCE EXPONENT,E12.3,/1H ,5X,
   3 20HITERATION NUMBER    ,8X,I4,/1H ,5X,
   4 20HITERATION TYPE      ,8X,I4)
```

```
8013 FORMAT(1H-,18HITERATIONS STOPPED,/1H ,
    1 33HLAST PERCENTAGE LIFE IS INCORRECT,
    2 /1H ,22HNO GROWTH HAS OCCURRED)
8014 FORMAT(1H0,10H    TABLE ,I4,': BETA C')
8015 FORMAT(1H0,12X,4H  A=,7(1PE11.3,4X),E11.3)
8016 FORMAT(1H ,2HC=,1PE10.3,8E15.3)
8017 FORMAT(1H0,10H    TABLE ,I4,': BETA A')
8018 FORMAT(1H-,16HPROOF INPUT DATA,/1H0,5X,10HPROOF TYPE,9X,I4,
    1 7X,4HLOWE,A4,1PE12.3,/1H ,5X,5HPROOF,6X,E12.3,7X,4HUPPE,A4,
    2 E12.3,/1H ,5X,11HKC PROOF   ,E12.3,7X,2A4,E12.3,/1H ,5X,
    3 11HKA PROOF   ,E12.3,7X,16HITERATION LIMIT ,I4)
8019 FORMAT(1H0,5X,13HMATERIAL TYPE,I4,5X,5HTABLE,I4)
8020 FORMAT(1H0,14X,4H RE=,7(1PE11.3,4X),E11.3)
8021 FORMAT(1H ,4HDKE=,1PE10.3,8E15.3)
     END
```

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```
      SUBROUTINE PROOF(A0,C0,XLOW,XUP,IEND,NPROOF)
      COMMON X(12,25),Y(12,25),TABLE(12,25,25),FIXED,KCPRF,KAPRF,
     1 PROOFX,NKTMX,NOX(12),NOY(12),NTAB(10),IPLOT,IFAIL,CUMSUM,PCYC(2)
      REAL KAPRF,KCPRF
      EXTERNAL FCT1,FCT2,FCT3,FCT4,FCT5,FCT6,FCT7
      IF (IEND.NE.0) GO TO 10
      IEND=100
   10 GO TO (100,200,300,400),NPROOF
C
  100 CONTINUE
      CALL RTMI(A1,ZERO,FCT1,XLOW,XUP,.001,IEND,IER)
      CALL MESS1(IER,A1,XUP)
      IERC=IER
      CALL RTMI(A2,ZERO,FCT2,XLOW,XUP,.001,IEND,IER)
      CALL MESS2(IER,A2,XUP)
      IERC=IERC*IER
      IF (IERC.NE.0) GO TO 2000
      A0=AMIN1(A1,A2)
      C0=A0/FIXED
      GO TO 1000
  200 CONTINUE
      CALL RTMI(C0,ZERO,FCT3,XLOW,XUP,.001,IEND,IER)
      CALL MESS2(IER,C0,XUP)
      IF (IER.NE.0) GO TO 2000
      GO TO 1000
  300 CONTINUE
      CALL RTMI(A1,ZERO,FCT4,XLOW,XUP,.001,IEND,IER)
      CALL MESS1(IER,A1,XUP)
      IERC=IER
      CALL RTMI(A2,ZERO,FCT5,XLOW,XUP,.001,IEND,IER)
      CALL MESS2(IER,A2,XUP)
      IERC=IERC*IER
      IF (IERC.NE.0) GO TO 2000
      A0=AMIN1(A1,A2)
      C0=FIXED
      GO TO 1000
  400 CONTINUE
      CALL RTMI(C1,ZERO,FCT6,XLOW,XUP,.001,IEND,IER)
      CALL MESS1(IER,C1,XUP)
      IERC=IER
      CALL RTMI(C2,ZERO,FCT7,XLOW,XUP,.001,IEND,IER)
      CALL MESS2(IER,C2,XUP)
      IERC=IERC*IER
      IF (IERC.NE.0) GO TO 2000
      C0=AMIN1(C1,C2)
      A0=FIXED
 1000 RETURN
 2000 STOP
      END
```

```
      SUBROUTINE MESS1(IER,X,XUP)
      IF (IER.NE.1) GO TO 600
      X=XUP
      WRITE(6,6010)
      GO TO 700
  600 IF (IER.NE.2) GO TO 700
      X=XUP
      WRITE(6,6020)
  700 RETURN
 6010 FORMAT(1H0,45HPROOF LOAD CALCULATION AT DEPTH HAS NOT CONVERGED)
 6020 FORMAT(1H0,39HBOUNDS ON VARIABLE ARE NOT APPROPRIATE.,/1H ,
     1 54HEITHER CRITICAL STRESS INTENSITY AT DEPTH IS LESS THAN,
     2 22H KPROOF AT LOWER BOUND,/1H ,26H  OR   GREATER THAN KPROOF,
     3 15H AT UPPER BOUND)
      END
```

```
      SUBROUTINE MESS2(IER,X,XUP)
      IF (IER.NE.1) GO TO 600
      X=XUP
      WRITE(6,6010)
      GO TO 700
  600 IF (IER.NE.2) GO TO 700
      X=XUP
      WRITE(6,6020)
  700 RETURN
 6010 FORMAT(1H0,51HPROOF LOAD CALCULATION AT SURFACE HAS NOT CONVERGED)
 6020 FORMAT(1H0,39HBOUNDS ON VARIABLE ARE NOT APPROPRIATE.,/1H ,
     1 56HEITHER CRITICAL STRESS INTENSITY AT SURFACE IS LESS THAN,
     2 22H KPROOF AT LOWER BOUND,/1H ,26H  OR   GREATER THAN KPROOF,
     3 15H AT UPPER BOUND)
      END
```

```
      SUBROUTINE RTMI(X,F,FCT,XLI,XRI,EPS,IEND,IER)
C
C     ..................................................................
C
C        SUBROUTINE RTMI
C
C        PURPOSE
C           TO SOLVE GENERAL NONLINEAR EQUATIONS OF THE FORM FCT(X)=0
C           BY MEANS OF MUELLER-S ITERATION METHOD.
C
C        USAGE
C           CALL RTMI (X,F,FCT,XLI,XRI,EPS,IEND,IER)
C           PARAMETER FCT REQUIRES AN EXTERNAL STATEMENT.
C
C        DESCRIPTION OF PARAMETERS
C           X      - RESULTANT ROOT OF EQUATION FCT(X)=0.
C           F      - RESULTANT FUNCTION VALUE AT ROOT X.
C           FCT    - NAME OF THE EXTERNAL FUNCTION SUBPROGRAM USED.
C           XLI    - INPUT VALUE WHICH SPECIFIES THE INITIAL LEFT BOUND
C                    OF THE ROOT X.
C           XRI    - INPUT VALUE WHICH SPECIFIES THE INITIAL RIGHT BOUND
C                    OF THE ROOT X.
C           EPS    - INPUT VALUE WHICH SPECIFIES THE UPPER BOUND OF THE
C                    ERROR OF RESULT X.
C           IEND   - MAXIMUM NUMBER OF ITERATION STEPS SPECIFIED.
C           IER    - RESULTANT ERROR PARAMETER CODED AS FOLLOWS
C                     IER=0 - NO ERROR,
C                     IER=1 - NO CONVERGENCE AFTER IEND ITERATION STEPS
C                             FOLLOWED BY IEND SUCCESSIVE STEPS OF
C                             BISECTION,
C                     IER=2 - BASIC ASSUMPTION FCT(XLI)*FCT(XRI) LESS
C                             THAN OR EQUAL TO ZERO IS NOT SATISFIED.
C
C        REMARKS
C           THE PROCEDURE ASSUMES THAT FUNCTION VALUES AT INITIAL
C           BOUNDS XLI AND XRI HAVE NOT THE SAME SIGN. IF THIS BASIC
C           ASSUMPTION IS NOT SATISFIED BY INPUT VALUES XLI AND XRI, THE
C           PROCEDURE IS BYPASSED AND GIVES THE ERROR MESSAGE IER=2.
C
C        SUBROUTINES AND FUNCTION SUBPROGRAMS REQUIRED
C           THE EXTERNAL FUNCTION SUBPROGRAM FCT(X) MUST BE FURNISHED
C           BY THE USER.
C
C        METHOD
C           SOLUTION OF EQUATION FCT(X)=0 IS DONE BY MEANS OF MUELLER-S
C           ITERATION METHOD OF SUCCESSIVE BISECTIONS AND INVERSE
C           PARABOLIC INTERPOLATION, WHICH STARTS AT THE INITIAL BOUNDS
C           XLI AND XRI. CONVERGENCE IS QUADRATIC IF THE DERIVATIVE OF
C           FCT(X) AT ROOT X IS NOT EQUAL TO ZERO. ONE ITERATION STEP
C           REQUIRES TWO EVALUATIONS OF FCT(X). FOR TEST ON SATISFACTORY
C           ACCURACY SEE FORMULAE (3,4) OF MATHEMATICAL DESCRIPTION.
C           FOR REFERENCE, SEE G. K. KRISTIANSEN, ZERO OF ARBITRARY
C           FUNCTION, BIT, VOL. 3 (1963), PP.205-206.
C
C     ..................................................................
C
C
C
C     PREPARE ITERATION
      IER=0
```

```
      XL=XLI
      XR=XRI
      X=XL
      TOL=X
      F=FCT(TOL)
      IF(F)1,16,1
    1 FL=F
      X=XR
      TOL=X
      F=FCT(TOL)
      IF(F)2,16,2
    2 FR=F
      IF(SIGN(1.,FL)+SIGN(1.,FR))25,3,25
C
C     BASIC ASSUMPTION FL*FR LESS THAN 0 IS SATISFIED.
C     GENERATE TOLERANCE FOR FUNCTION VALUES.
    3 I=0
      TOLF=100.*EPS
C
C
C     START ITERATION LOOP
    4 I=I+1
C
C     START BISECTION LOOP
      DO 13 K=1,IEND
      X=.5*(XL+XR)
      TOL=X
      F=FCT(TOL)
      IF(F)5,16,5
    5 IF(SIGN(1.,F)+SIGN(1.,FR))7,6,7
C
C     INTERCHANGE XL AND XR IN ORDER TO GET THE SAME SIGN IN F AND FR
    6 TOL=XL
      XL=XR
      XR=TOL
      TOL=FL
      FL=FR
      FR=TOL
    7 TOL=F-FL
      A=F*TOL
      A=A+A
      IF(A-FR*(FR-FL))8,9,9
    8 IF(I-IEND)17,17,9
    9 XR=X
      FR=F
C
C     TEST ON SATISFACTORY ACCURACY IN BISECTION LOOP
      TOL=EPS
      A=ABS(XR)
      IF(A-1.)11,11,10
   10 TOL=TOL*A
   11 IF(ABS(XR-XL)-TOL)12,12,13
   12 IF(ABS(FR-FL)-TOLF)14,14,13
   13 CONTINUE
C     END OF BISECTION LOOP
C
C     NO CONVERGENCE AFTER IEND ITERATION STEPS FOLLOWED BY IEND
C     SUCCESSIVE STEPS OF BISECTION OR STEADILY INCREASING FUNCTION
C     VALUES AT RIGHT BOUNDS. ERROR RETURN.
      IER=1
```

```
   14 IF(ABS(FR)-ABS(FL))16,16,15                                        RTMI1210
   15 X=XL                                                              RTMI1220
      F=FL                                                              RTMI1230
   16 RETURN                                                            RTMI1240
C                                                                       RTMI1250
C     COMPUTATION OF ITERATED X-VALUE BY INVERSE PARABOLIC INTERPOLATIONRTMI1260
   17 A=FR-F                                                            RTMI1270
      DX=(X-XL)*FL*(1.+F*(A-TOL)/(A*(FR-FL)))/TOL                       RTMI1280
      XM=X                                                              RTMI1290
      FM=F                                                              RTMI1300
      X=XL-DX                                                           RTMI1310
      TOL=X                                                             RTMI1320
      F=FCT(TOL)                                                        RTMI1330
      IF(F)18,16,18                                                     RTMI1340
C                                                                       RTMI1350
C     TEST ON SATISFACTORY ACCURACY IN ITERATION LOOP                   RTMI1360
   18 TOL=EPS                                                           RTMI1370
      A=ABS(X)                                                          RTMI1380
      IF(A-1.)20,20,19                                                  RTMI1390
   19 TOL=TOL*A                                                         RTMI1400
   20 IF(ABS(DX)-TOL)21,21,22                                           RTMI1410
   21 IF(ABS(F)-TOLF)16,16,22                                           RTMI1420
C                                                                       RTMI1430
C     PREPARATION OF NEXT BISECTION LOOP                                RTMI1440
   22 IF(SIGN(1.,F)+SIGN(1.,FL))24,23,24                                RTMI1450
   23 XR=X                                                              RTMI1460
      FR=F                                                              RTMI1470
      GO TO 4                                                           RTMI1480
   24 XL=X                                                              RTMI1490
      FL=F                                                              RTMI1500
      XR=XM                                                             RTMI1510
      FR=FM                                                             RTMI1520
      GO TO 4                                                           RTMI1530
C     END OF ITERATION LOOP                                             RTMI1540
C                                                                       RTMI1550
C                                                                       RTMI1560
C     ERROR RETURN IN CASE OF WRONG INPUT DATA                          RTMI1570
   25 IER=2                                                             RTMI1580
      RETURN                                                            RTMI1590
      END                                                               RTMI1600
```

```
      FUNCTION FCT1(AF)
      COMMON X(12,25),Y(12,25),TABLE(12,25,25),FIXED,KCPRF,KAPRF,
     1 PROOFX,NKTMX,NOX(12),NOY(12),NTAB(10),IPLOT,IFAIL,CUMSUM,PCYC(2)
      COMMON A,AP(2),ALIM,AOL(2),C,CB,CLIM,CR(2,10,10),CO,CUME,
     1 CUMELM,C1B1,D(2,10,10),DK,DKE,DXDX,FA,FC,H,INC,KCL,KC1,KOL,
     2 KOA,KOC,KCRA,KCRC,KMAX,OA,OC,PI,R,RAD,RE,RYOL(2),ROL(2),
     3 SIG,SIGLM,SIGY,SIGYS(10),SMIN(422),SMAX(422),TH,
     4 UNIT(422),W,DCTMP,DELTMP,DXTMP,
     5 ALOWN,BLOCK,FLAG1,I,ICD(2),ICK(2),ICR(2),IBLOCK,IFIRST,IPRN(4),
     6 ISTEP,ITRANS,J,KTYPE(2),NC,NEQ(10),NR,NRET(10),TYPE,TITL
      INTEGER ALOWN,BLOCK,FLAG1,TYPE(422),TITL(20)
      REAL KCL,KC1,KOL,KOA(10),KOC(10),KCRA(10),KCRC(10),KMAX,INC
      REAL KCPRF,KAPRF
      A=AF
      C=A/FIXED
      CALL KANAL
      FCT1=-KAPRF+FA*PROOFX
      RETURN
      END
```

```
      FUNCTION FCT2(AF)
      COMMON X(12,25),Y(12,25),TABLE(12,25,25),FIXED,KCPRF,KAPRF,
     1 PROOFX,NKTMX,NOX(12),NOY(12),NTAB(10),IPLOT,IFAIL,CUMSUM,PCYC(2)
      COMMON A,AP(2),ALIM,ADL(2),C,CB,CLIM,CR(2,10,10),CO,CUME,
     1 CUMELM,C1B1,D(2,10,10),DK,DKE,DXDX,FA,FC,H,INC,KCL,KC1,KOL,
     2 KOA,KOC,KCRA,KCRC,KMAX,OA,OC,PI,R,RAD,RE,RYOL(2),ROL(2),
     3 SIG,SIGLM,SIGY,SIGYS(10),SMIN(422),SMAX(422),TH,
     4 UNIT(422),W,DCTMP,DELTMP,DXTMP,
     5 ALOWN,BLOCK,FLAG1,I,ICD(2),ICK(2),ICR(2),IBLOCK,IFIRST,IPRN(4),
     6 ISTEP,ITRANS,J,KTYPE(2),NC,NEQ(10),NR,NRET(10),TYPE,TITL
      INTEGER ALOWN,BLOCK,FLAG1,TYPE(422),TITL(20)
      REAL KCL,KC1,KOL,KOA(10),KOC(10),KCRA(10),KCRC(10),KMAX,INC
      REAL KCPRF,KAPRF
      A=AF
      C=A/FIXED
      CALL KANAL
      FCT2=-KCPRF+FC*PROOFX
      RETURN
      END
```

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      FUNCTION FCT3(CF)
      COMMON X(12,25),Y(12,25),TABLE(12,25,25),FIXED,KCPRF,KAPRF,
     1 PROOFX,NKTMX,NOX(12),NOY(12),NTAB(10),IPLOT,IFAIL,CUMSUM,PCYC(2)
      COMMON A,AP(2),ALIM,AOL(2),C,CB,CLIM,CR(2,10,10),CO,CUME,
     1 CUMELM,C1B1,D(2,10,10),DK,DKE,DXDX,FA,FC,H,INC,KCL,KC1,KOL,
     2 KOA,KOC,KCRA,KCRC,KMAX,OA,OC,PI,R,RAD,RE,RVOL(2),ROL(2),
     3 SIG,SIGLM,SIGY,SIGYS(10),SMIN(422),SMAX(422),TH,
     4 UNIT(422),W,DCTMP,DELTMP,DXTMP,
     5 ALOWN,BLOCK,FLAG1,I,ICD(2),ICK(2),ICR(2),IBLOCK,IFIRST,IPRN(4),
     6 ISTEP,ITRANS,J,KTYPE(2),NC,NEQ(10),NR,NRET(10),TYPE,TITL
      INTEGER ALOWN,BLOCK,FLAG1,TYPE(422),TITL(20)
      REAL KCL,KC1,KOL,KOA(10),KOC(10),KCRA(10),KCRC(10),KMAX,INC
      REAL KCPRF,KAPRF
      C=CF
      CALL KANAL
      FCT3=-KCPRF+FC*PROOFX
      RETURN
      END
```

```
      FUNCTION FCT4(AF)
      COMMON X(12,25),Y(12,25),TABLE(12,25,25),FIXED,KCPRF,KAPRF,
     1 PROOFX,NKTMY,NOX(12),NOY(12),NTAB(10),IPLOT,IFAIL,CUMSUM,PCYC(2)
      COMMON A,AP(2),ALIM,AOL(2),C,CB,CLIM,CR(2,10,10),CO,CUMF,
     1 CUMELM,C1B1,D(2,10,10),DK,DKE,DXDX,FA,FC,H,INC,KCL,KC1,KOL,
     2 KOA,KOC,KCRA,KCRC,KMAX,OA,OC,PI,R,RAD,RE,RVOL(2),ROL(2),
     3 SIG,SIGLM,SIGY,SIGYS(10),SMIN(422),SMAX(422),TH,
     4 UNIT(422),W,DCTMP,DELTMP,DXTMP,
     5 ALOWN,BLOCK,FLAG1,I,ICD(2),ICK(2),ICR(2),IBLOCK,IFIRST,IPRN(4),
     6 ISTEP,ITRANS,J,KTYPE(2),NC,NEQ(10),NR,NRET(10),TYPE,TITL
      INTEGER ALOWN,BLOCK,FLAG1,TYPE(422),TITL(20)
      REAL KCL,KC1,KOL,KOA(10),KOC(10),KCRA(10),KCRC(10),KMAX,INC
      REAL KCPRF,KAPRF
      A=AF
      C=FIXED
      CALL KANAL
      FCT4=-KAPRF+FA*PROOFX
      RETURN
      END
```

```
      FUNCTION FCT5(AF)
      COMMON X(12,25),Y(12,25),TABLE(12,25,25),FIXED,KCPRF,KAPRF,
     1 PROOFX,NKTMX,NOX(12),NOY(12),NTAB(10),IPLOT,IFAIL,CUMSUM,PCYC(2)
      COMMON A,AP(2),ALIM,AOL(2),C,CB,CLIM,CR(2,10,10),CO,CUME,
     1 CUMELM,C1B1,D(2,10,10),DK,DKE,DXDX,FA,FC,H,INC,KCL,KC1,KOL,
     2 KOA,KOC,KCRA,KCRC,KMAX,OA,OC,PI,R,RAD,RE,RVOL(2),ROL(2),
     3 SIG,SIGLM,SIGY,SIGYS(10),SMIN(422),SMAX(422),TH,
     4 UNIT(422),W,DCTMP,DELTMP,DXTMP,
     5 ALOWN,BLOCK,FLAG1,I,ICD(2),ICK(2),ICR(2),IBLOCK,IFIRST,IPRN(4),
     6 ISTEP,ITRANS,J,KTYPE(2),NC,NEQ(10),NR,NRET(10),TYPE,TITL
      INTEGER ALOWN,BLOCK,FLAG1,TYPE(422),TITL(20)
      REAL KCL,KC1,KOL,KOA(10),KOC(10),KCRA(10),KCRC(10),KMAX,INC
      REAL KCPRF,KAPRF
      A=AF
      C=FIXED
      CALL KANAL
      FCT5=-KCPRF+FC*PROOFX
      RETURN
      END
```

```
      FUNCTION FCT6(CF)
      COMMON X(12,25),Y(12,25),TABLE(12,25,25),FIXED,KCPRF,KAPRF,
     1 PROOFX,NKTMX,NOX(12),NOY(12),NTAB(10),IPLOT,IFAIL,CUMSUM,PCYC(2)
      COMMON A,AP(2),ALIM,AOL(2),C,CB,CLIM,CR(2,10,10),CO,CUME,
     1 CUMELM,C1B1,D(2,10,10),DK,DKE,DXDX,FA,FC,H,INC,KCL,KC1,KOL,
     2 KOA,KOC,KCRA,KCRC,KMAX,OA,OC,PI,R,RAD,RE,RYOL(2),ROL(2),
     3 SIG,SIGLM,SIGY,SIGYS(10),SMIN(422),SMAX(422),TH,
     4 UNIT(422),W,DCTMP,DELTMP,DXTMP,
     5 ALOWN,BLOCK,FLAG1,I,ICD(2),ICK(2),ICR(2),IBLOCK,IFIRST,IPRN(4),
     6 ISTEP,ITRANS,J,KTYPE(2),NC,NEQ(10),NR,NRET(10),TYPE,TITL
      INTEGER ALOWN,BLOCK,FLAG1,TYPE(422),TITL(20)
      REAL KCL,KC1,KOL,KOA(10),KOC(10),KCRA(10),KCRC(10),KMAX,INC
      REAL KCPRF,KAPRF
      C=CF
      A=FIXED
      CALL KANAL
      FCT6=-KAPRF+FA*PROOFX
      RETURN
      END
```

```
      FUNCTION FCT7(CF)
      COMMON X(12,25),Y(12,25),TABLE(12,25,25),FIXED,KCPRF,KAPRF,
     1 PROOFX,NKTMX,NOX(12),NOY(12),NTAB(10),IPLOT,IFAIL,CUMSUM,PCYC(2)
      COMMON A,AP(2),ALIM,AOL(2),C,CB,CLIM,CR(2,10,10),CO,CUMF,
     1 CUMELM,C1B1,D(2,10,10),DK,DKE,DXDX,FA,FC,H,INC,KCL,KC1,KOL,
     2 KOA,KOC,KCRA,KCRC,KMAX,OA,OC,PI,R,RAD,RE,RYOL(2),ROL(2),
     3 SIG,SIGLM,SIGY,SIGYS(10),SMIN(422),SMAX(422),TH,
     4 UNIT(422),W,DCTMP,DELTMP,DXTMP,
     5 ALOWN,BLOCK,FLAG1,I,ICD(2),ICK(2),ICR(2),IBLOCK,IFIRST,IPRN(4),
     6 ISTEP,ITRANS,J,KTYPE(2),NC,NEQ(10),NR,NRET(10),TYPE,TITL
      INTEGER ALOWN,BLOCK,FLAG1,TYPE(422),TITL(20)
      REAL KCL,KC1,KOL,KOA(10),KOC(10),KCRA(10),KCRC(10),KMAX,INC
      REAL KCPRF,KAPRF
      C=CF
      A=FIXED
      CALL KANAL
      FCT7=-KCPRF+FC*PROOFX
      RETURN
      END
```

```
      SUBROUTINE PTCGRW
      COMMON X(12,25),Y(12,25),TABLE(12,25,25),FIXED,KCPRF,KAPRF,
     1 PROOFX,NKTMX,NOX(12),NOY(12),NTAB(10),IPLOT,IFAIL,CUMSUM,PCYC(2)
      COMMON A,AP(2),ALIM,AOL(2),C,CB,CLIM,CR(2,10,10),CO,CUME,
     1 CUMELM,C1B1,D(2,10,10),DK,DKE,DXDX,FA,FC,H,INC,KCL,KC1,KOL,
     2 KOA,KOC,KCRA,KCRC,KMAX,OA,OC,PI,R,RAD,RE,RYOL(2),ROL(2),
     3 SIG,SIGLM,SIGY,SIGYS(10),SMIN(422),SMAX(422),TH,
     4 UNIT(422),W,DCTMP,DELTMP,DXTMP,
     5 ALOWN,BLOCK,FLAG1,I,ICP(2),ICK(2),ICR(2),IBLOCK,IFIRST,IPRN(4),
     6 ISTEP,ITRANS,J,KTYPE(2),NC,NEQ(10),NR,NRET(10),TYPE,TITL
      INTEGER ALOWN,BLOCK,FLAG1,TYPE(422),TITL(20)
      REAL KCL,KC1,KOL,KOA(10),KOC(10),KCRA(10),KCRC(10),KMAX
      REAL INC,KA,KC,KAPRF,KCPRF
      K=0
      IFIRST=1
      J=TYPE(I)
 1025 DEL=INC*A
      IF (NRET(J)) 1050,1050,1030
 1030 IF (ABS(RYOL(2))-.0001) 1050,1050,1038
 1038 IF (DEL-.1*RYOL(2)) 1050,1050,1040
 1040 DEL=.1*RYOL(2)
 1050 A=A+DEL
      K1=KTYPE(2)
      GO TO (1054,1054,1054,1054,1056,1056,1054,1054,1054,1056,1056,
     1 1054,1054,1056,1056,1054,1056), K1
C
C     NOT INTERNAL TYPE CRACK
C
 1054 TEMP=TH
      GO TO 1058
C
C     INTERNAL TYPE CRACK
C
 1056 TEMP=TH/2.
 1058 IF (ABS(A-DEL-TEMP)-1.E-6) 1060,1060,1070
 1060 IF (KTYPE(2).EQ.7) GO TO 1065
      KTYPE(1)=2
      CALL TRANS
      RETURN
 1065 WRITE(6,6110)
      ICR(1)=-1
      CUMSUM=CUMSUM+CUME
      RETURN
 1070 IF (A-TEMP) 1090,1090,1080
 1080 DEL=TEMP-A+DEL
      A=TEMP
 1090 SIGY=SIGYS(J)
      IF (FLAG1) 1130,1100,1130
 1100 R=0
      SIG=SIGLM
      CALL KANAL
      IF (SIGLM*FA-KCRA(J)) 1110,1110,1120
 1110 IF (SIGLM*FC-KCRC(J)) 1130,1130,1120
 1120 FLAG1=1
      ALIM=A
      CLIM=C
      IBLOCK=BLOCK
      ISTEP=I
      CUMELM=CUME
 1130 A=A-DEL/2
```

```
      SIG=SMAX(I)
      R=SMIN(I)/SMAX(I)
      CALL KANAL
      A=A-DEL/2
      KA=FA*SIG
      KC=FC*SIG
      DKA=(1-R)*KA
      DKC=(1-R)*KC
      IF (KA-KCRA(J)) 1140,1140,1150
 1140 IF (KC-KCRC(J)) 1160,1160,1153
 1150 IF (FLAG1) 1152,1152,1151
 1151 WRITE(6,6019) IBLOCK,ISTEP,CUMELM
 1152 WRITE (6,6002) BLOCK,I,CUME
      IFAIL=1
      CUMSUM=CUMSUM+CUME
      ICR(I)=-1
      RETURN
 1153 IF (FLAG1) 1155,1155,1154
 1154 WRITE(6,6019) IBLOCK,ISTEP,CUMELM
 1155 WRITE (6,6003) BLOCK,I,CUME
      IFAIL=2
      CUMSUM=CUMSUM+CUME
      ICR(I)=-1
      RETURN
 1160 IF (KOA(J)-DKA) 1180,1170,1170
 1170 DADX=0
      IF (KOC(J)-DKC) 1190,1172,1172
 1172 K=1
      DCDX=0
      GO TO 1211
 1180 KMAX=KA
      DK=DKA
      NC=2
      CALL DAMAGE
      IF (DXDX) 1191,1182,1182
 1182 CONTINUE
      DADX=DXDX
      IF (KOC(J)-DKC) 1190,1200,1200
 1190 KMAX=KC
      DK=DKC
      NC=1
      CALL DAMAGE
      IF (DXDX) 1191,1192,1192
 1191 ICR(I)=-1
      CUMSUM=CUMSUM+CUME
      WRITE(6,6100)
      RETURN
 1192 CONTINUE
      DCDX=DXDX
      GO TO 1210
 1200 DCDX=0
 1210 AVAIL=UNIT(I)-CUME
      IF (A*C*DCDX*DADX.EQ.0) GO TO 1211
      ADJ=5.*DADX/A/(DCDX/C)
      IF (ADJ.GE.1.) GO TO 1211
      DEL=ADJ*DEL
 1211 IF (IPRN(1)-IPRN(4)) 1201,1205,1205
 1201 IF (IPRN(1)) 1202,1203,1203
 1202 WRITE(6,8002) NR,TITL
      WRITE(6,8003)
```

```
      IPRN(1)=0
      DELTMP=0.
      DCTMP=0.
      DXTMP=0.
 1203 IF (IFIRST-1) 1205,1204,1205
 1204 IFIRST=0
      IPRN(1)=IPRN(1)+1
      WRITE(6,8004) BLOCK,I,CUME,C,A,KC,KA,DCDX,DADX
      IF (K) 5000,1205,5000
 1205 CONTINUE
      IF (ALOWN-1) 1230,1220,1230
 1220 DX=1
      DEL=DADX
      DC=DCDX
      GO TO 1260
 1230 IF (DADX) 1235,1265,1235
 1235 IF (DEL/DADX-AVAIL) 1250,1250,1240
 1240 DELTMP=DELTMP+AVAIL*DADX
      IF (A) 1241,1242,1241
 1241 IF (DELTMP/A-1.E-4) 1244,1244,1242
 1242 A=A+DELTMP
      DELTMP=0.
 1244 DCTMP=DCTMP+AVAIL*DCDX
      IF (C) 1245,1246,1245
 1245 IF (DCTMP/C-1.E-4) 5000,5000,1246
 1246 C=C+DCTMP
      DCTMP=0.
      GO TO 5000
 1250 DX=DEL/DADX
      DC=DX*DCDX
      GO TO 1260
 1265 DC=INC*C
      IF (RYOL(1)-1.E-4) 1258,1258,1256
 1256 IF (NRET(J)) 1257,1258,1257
 1257 DC=AMIN1(.1*RYOL(1),DC)
 1258 IF (DCDX) 5000,5000,1259
 1259 DX=DC/DCDX
      DEL=DX*DADX
 1260 IF (DX-AVAIL) 1280,1280,1270
 1270 DELTMP=DELTMP+AVAIL*DADX
      IF (A) 1271,1272,1271
 1271 IF (DELTMP/A-1.E-4) 1274,1274,1272
 1272 A=A+DELTMP
      DELTMP=0.
 1274 DCTMP=DCTMP+AVAIL*DCDX
      IF (C) 1275,1276,1275
 1275 IF (DCTMP/C-1.E-4) 5000,5000,1276
 1276 C=C+DCTMP
      DCTMP=0.
      GO TO 5000
 1280 DELTMP=DELTMP+DEL
      IF (A) 1281,1282,1281
 1281 IF (DELTMP/A-1.E-4) 1284,1284,1282
 1282 A=A+DELTMP
      DELTMP=0.
 1284 DCTMP=DCTMP+DC
      IF (C) 1285,1286,1285
 1285 IF (DCTMP/C-1.E-4) 1288,1288,1286
 1286 C=C+DCTMP
      DCTMP=0.
```

```
1288 DXTMP=DXTMP+DX
     IF (IPLOT.NE.2) GO TO 1300
     CUMTMP=CUMSUM+CUME
     IF (CUMTMP.LT.PCYC(2)) GO TO 1300
     WRITE(7,7000) A,C,CUMTMP
     PCYC(2)=PCYC(2)+PCYC(1)
1300 IF (CUME) 1289,1290,1289
1289 IF (DXTMP/CUME-1.E-4) 1025,1025,1290
1290 CUME=CUME+DXTMP
     DXTMP=0.
     GO TO 1025
5000 CONTINUE
     CUME=UNIT(I)
     CUMSUM=CUMSUM+UNIT(I)
     IF (IPLOT.NE.2) GO TO 5005
     IF (CUMSUM.LT.PCYC(2)) GO TO 5005
     WRITE(7,7000) A,C,CUMSUM
     PCYC(2)=PCYC(2)+PCYC(1)
5005 IF (IPRN(1)-IPRN(4)) 5010,5020,5020
5010 IPRN(1) = IPRN(1)+1
     WRITE(6,8005) BLOCK,I,CUME,C,A,KC,KA,DCDX,DADX
     IF (IPLOT.NE.1) GO TO 5020
     WRITE(7,7000) A,C,CUMSUM
5020 CONTINUE
     RETURN
6002 FORMAT(45HOCRITICAL K AT DEPTH HAS BEEN EXCEEDED IN THE,I6,
    1 14H BLOCK AND THE,I4,11H STEP AFTER,1PE12.3,7H CYCLES )
6003 FORMAT(47HOCRITICAL K AT SURFACE HAS BEEN EXCEEDED IN THE,I6,
    1 14H BLOCK AND THE,I4,11H STEP AFTER,1PE12.3,7H CYCLES )
6019 FORMAT(35HOLIMIT LOAD FRACTURE OCCURS IN THE ,I6,7H BLOCK ,
    1 I4,12H STEP AFTER ,1PE12.3,7H CYCLES)
6100 FORMAT(1H0,29HCRACK GROWTH RATE IS NEGATIVE,/1H ,
    1 46HACCEPTABLE END OF LIFE IF FORMUN EQUATION USED)
6110 FORMAT(/1H0,46HCRACK IN TRANSITION. NEED TABLES FOR ANALYSIS.)
7000 FORMAT(4HDATA,1P3E12.3)
8002 FORMAT(5H1RUN ,I4,5X,20A4,/1H0,50X,26HCRACK IS A PART THRU CRACK,
    1 /1H0,42X,12HHALF SURFACE,50X,7HSURFACE,9X,5HDEPTH)
8003 FORMAT(1H ,12X,45HBLOCK   STEP         CYCLES        CRACK LENGTH    ,
    156HCRACK DEPTH    KMAX-SURFACE    KMAX-DEPTH    GROWTH RATE,4X,
    211HGROWTH RATE,/1H ,46X,4H(IN),11X,4H(IN),6X,13H(KSI ROOT-IN),2X,
    313H(KSI ROOT-IN),4X,10H(IN/CYCLE),5X,10H(IN/CYCLE),//)
8004 FORMAT(10H                  ,I6,3X,I4,7(3X,1PE12.3))
8005 FORMAT(10H                  ,I6,3X,I4,7(3X,1PE12.3))
     END
```

```
      SUBROUTINE TRANS
      COMMON X(12,25),Y(12,25),TABLE(12,25,25),FIXED,KCPRF,KAPRF,
     1 PRODFX,NKTMX,NOX(12),NOY(12),NTAB(10),IPLOT,IFAIL,CUMSUM,PCYC(2)
      COMMON A,AP(2),ALIM,AOL(2),C,CB,CLIM,CR(2,10,10),CO,CUME,
     1 CUMELM,C1B1,D(2,10,10),DK,DKE,DXDX,FA,FC,H,INC,KCL,KC1,KOL,
     2 KOA,KOC,KCRA,KCRC,KMAX,OA,OC,PI,R,RAD,RE,RYOL(2),ROL(2),
     3 SIG,SIGLM,SIGY,SIGYS(10),SMIN(422),SMAX(422),TH,
     4 UNIT(422),W,DCTMP,DELTMP,DXTMP,
     5 ALOWN,BLOCK,FLAG1,I,ICD(2),ICK(2),ICR(2),IBLOCK,IFIRST,IPRN(4),
     6 ISTEP,ITRANS,J,KTYPE(2),NC,NEQ(10),NR,NRET(10),TYPE,TITL
      INTEGER ALOWN,BLOCK,FLAG1,TYPE(422),ONSTEP,TITL(20)
      REAL KCL,KC1,KOL,KOA(10),KOC(10),KCRA(10),KCRC(10),KMAX,INC
      REAL KA,KC,KAPRF,KCPRF
      K=0
      IFIRST=1
      IF (ITRANS-1) 10,180,10
   10 CONTINUE
      ITRANS=1
      KORIG=KTYPE(1)
      KTYPE(1)=3
      FLAG2=0
      CALL KANAL
      IF (FC*SMAX(I)-KCRC(J)) 110,110,100
  100 WRITE(6,6021) BLOCK,I,CUME
      CUMSUM=CUMSUM+CUME
      IFAIL=3
      ICR(1)=-1
      RETURN
  110 IF (FLAG1) 140,120,140
  120 IF (FC*SIGLM-KCRC(J)) 140,140,130
  130 FLAG1=1
      ALIM=A
      CLIM=C
      IBLOCK=BLOCK
      ISTEP=I
      CUMELM=CUME
  140 CB=.01
      KTYPE(1)=KORIG
      SIGY=SIGYS(J)
      SIG=SMAX(I)
      R=SMIN(I)/SIG
  150 CALL KANAL
      IF (FA*SIG-KCRC(J)) 180,180,160
  160 CB=CB+.02*C
      FLAG2=1
      IF (CB-C) 150,170,170
  170 WRITE(6,6022) BLOCK,I,CUME
      WRITE(6,6023) CB,C
      IFAIL=4
      ICR(1)=-1
      CUMSUM=CUMSUM+CUME
      RETURN
  180 DEL=INC*CB
      IF (NRET(J)) 209,209,201
  201 IF (ABS(RYOL(1))-.0001) 209,209,202
  202 IF (DEL-.1*RYOL(1)) 209,209,203
  203 DEL=.1*RYOL(1)
  209 CB=CB+DEL
      IF (CB-.95*C) 220,220,210
  210 ITRANS=0
```

```
      IF (KTYPE(1).NE.2) GO TO 215
      KTYPE(1)=3
      CALL TCGROW
      RETURN
  215 WRITE(6,6110)
      ICR(1)=-1
      CUMSUM=CUMSUM+CUME
      RETURN
  220 CONTINUE
      SIG=SIGLM
      CALL KANAL
      IF (SIGLM*FA-KCRC(J)) 1110,1110,1120
 1110 IF (SIGLM*FC-KCRC(J)) 1130,1130,1120
 1120 FLAGI=1
      CBLIM=CB
      CLIM=C
      IBLOCK=BLOCK
      ISTEP=I
      CUMELM=CUME
 1130 CB=CB-DEL/2
      SIG=SMAX(I)
      R=SMIN(I)/SMAX(I)
      CALL KANAL
      CB=CB-DEL/2
      KA=FA*SIG
      KC=FC*SIG
      DKA=(1-R)*KA
      DKC=(1-R)*KC
      IF (KA-KCRC(J)) 1140,1140,1150
 1140 IF (KC-KCRC(J)) 1160,1160,1153
 1150 IF (FLAGI) 1152,1152,1151
 1151 WRITE(6,6019) IBLOCK,ISTEP,CUMELM
 1152 WRITE (6,6002) BLOCK,I,CUME
      CUMSUM=CUMSUM+CUME
      IFAIL=1
      ICR(1)=-1
      RETURN
 1153 IF (FLAGI) 1155,1155,1154
 1154 WRITE(6,6019) IBLOCK,ISTEP,CUMELM
 1155 WRITE (6,6003) BLOCK,I,CUME
      CUMSUM=CUMSUM+CUME
      IFAIL=2
      ICR(1)=-1
      RETURN
 1160 IF (KOC(J)-DKA) 1180,1170,1170
 1170 DADX=0
      IF (KOC(J)-DKC) 1190,1172,1172
 1172 K=1
      GO TO 1209
 1180 KMAX=KA
      DK=DKA
      NC=1
      CALL DAMAGE
      IF (DXDX) 1192,1184,1184
 1184 DADX=DXDX
      IF (KOC(J)-DKC) 1190,1200,1200
 1190 KMAX=KC
      DK=DKC
      NC=1
      CALL DAMAGE
```

```
      IF (DXDX) 1192,1194,1194
 1192 ICR(1)=-1
      WRITE(6,6100)
      CUMSUM=CUMSUM+CUME
      RETURN
 1194 DCDX=DXDX
      GO TO 1210
 1200 DCDX=0
 1210 AVAIL=UNIT(I)-CUME
 1209 IF (IPRN(3)-IPRN(4)) 1211,1215,1215
 1211 IF (IPRN(3)) 1212,1213,1213
 1212 WRITE(6,8002) NF,TITL
      WRITE(6,8003)
      IPRN(3)=0
      DELTMP=0.
      DCTMP=0.
      DXTMP=0.
 1213 IF (IFIRST-1) 1215,1214,1215
 1214 IFIRST=0
      IPRN(3)=IPRN(3)+1
      WRITE(6,8004) BLOCK,I,CUME,C,CB,KC,KA,DCDX,DADX
      IF (K) 5000,1215,5000
 1215 CONTINUE
      IF (ALOWN-1) 1230,1220,1230
 1220 DX=1
      DEL=DADX
      DC=DCDX
      GO TO 1260
 1230 IF (DADX) 1235,1255,1235
 1235 IF (DEL/DADX-AVAIL) 1250,1250,1240
 1240 DELTMP=DELTMP+AVAIL*DADX
      IF (CB) 1241,1242,1241
 1241 IF (DELTMP/CB-1.E-4) 1244,1244,1242
 1242 CB=CB+DELTMP
      DELTMP=0.
 1244 DCTMP=DCTMP+AVAIL*DCDX
      IF (C) 1245,1246,1245
 1245 IF (DCTMP/C-1.E-4) 5000,5000,1246
 1246 C=C+DCTMP
      DCTMP=0.
      GO TO 5000
 1250 DX=DEL/DADX
      DC=DX*DCDX
      GO TO 1260
 1255 DC=INC*C
      IF (RYDL(I)-1.E-4) 1258,1258,1256
 1256 IF (NRET(J)) 1257,1258,1257
 1257 DC=AMIN1(.1*RYDL(I),DC)
 1258 IF (DCDX) 5000,5000,1259
 1259 DX=DC/DCDX
      DEL=DX*DADX
 1260 IF (DX-AVAIL) 1280,1280,1270
 1270 DELTMP=DELTMP+AVAIL*DADX
      IF (CB) 1271,1272,1271
 1271 IF (DELTMP/CB-1.E-4) 1274,1274,1272
 1272 CB=CB+DELTMP
      DELTMP=0.
 1274 DCTMP=DCTMP+AVAIL*DCDX
      IF (C) 1275,1276,1275
 1275 IF (DCTMP/C-1.E-4) 5000,5000,1276
```

```
 1276 C=C+DCTMP
      DCTMP=0.
      GO TO 5000
 1280 DELTMP=DELTMP+DEL
      IF (CB) 1281,1282,1281
 1281 IF (DELTMP/CB-1.E-4) 1284,1284,1282
 1282 CB=CB+DELTMP
      DELTMP=0.
 1284 DCTMP=DCTMP+DC
      IF (C) 1285,1286,1285
 1285 IF (DCTMP/C-1.E-4) 1288,1288,1286
 1286 C=C+DCTMP
      DCTMP=0.
 1288 DXTMP=DXTMP+DX
      IF (IPLOT.NE.2) GO TO 1300
      CUMTMP=CUMSUM+CUME
      IF (CUMTMP.LT.PCYC(2)) GO TO 1300
      WRITE(7,7000) A,C,CUMTMP
      PCYC(2)=PCYC(2)+PCYC(1)
 1300 IF (CUME) 1289,1290,1289
 1289 IF (DXTMP/CUME-1.E-4) 180,180,1290
 1290 CUME=CUME+DXTMP
      DXTMP=0.
      GO TO 180
 5000 CONTINUE
      CUME=UNIT(I)
      CUMSUM=CUMSUM+CUME
      IF (IPLOT.NE.2) GO TO 5005
      IF (CUMSUM.LT.PCYC(2)) GO TO 5005
      WRITE(7,7000) A,C,CUMSUM
      PCYC(2)=PCYC(2)+PCYC(1)
 5005 IF (IPRN(3)-IPRN(4)) 5010,5020,5020
 5010 IPRN(3)=IPRN(3)+1
      WRITE(6,8005) BLOCK,I,CUME,C,CB,KC,KA,DCDX,DADX
      IF (IPLOT.NE.1) GO TO 5020
      WRITE(7,7000) A,C,CUMSUM
 5020 CONTINUE
      RETURN
 6002 FORMAT(45HOCRITICAL K AT DEPTH HAS BEEN EXCEEDED IN THE,I6,
     1 14H BLOCK AND THE,I4,11H STEP AFTER,1PE12.3,7H CYCLES )
 6003 FORMAT(47HOCRITICAL K AT SURFACE HAS BEEN EXCEEDED IN THE,I6,
     1 14H BLOCK AND THE,I4,11H STEP AFTER,1PE12.3,7H CYCLES )
 6019 FORMAT(35HOLIMIT LOAD FRACTURE OCCURS IN THE ,I6,7H BLOCK ,
     1 I4,12H STEP AFTER ,1PE12.3,7H CYCLES)
 6021 FORMAT(43HOFRACTURE OCCURS DURING BREAKTHROUGH IN THE,
     1 I6,14H BLOCK AND THE,I4,11H STEP AFTER,1PE12.3,7H CYCLES)
 6022 FORMAT(41HOFRACTURE OCCURS DURING TRANSITION IN THE,
     1 I6,14H BLOCK AND THE,I4,11H STEP AFTER,1PE12.3,7H CYCLES)
 6023 FORMAT(6HOCB = ,1PE12.3,7H    C = ,E12.3)
 6100 FORMAT(1HO,29HCRACK GROWTH RATE IS NEGATIVE,/1H ,
     1 46HACCEPTABLE END OF LIFE IF FROMUN EQUATION USED)
 6110 FORMAT(1HO,50HCRACK BECOMING THRU-CRACK. NEED TABLES FOR ANALYSI,
     1 2HS.)
 7000 FORMAT(4HDATA,1P3E12.3)
 8002 FORMAT(5H1RUN ,I4,5X,20A4,/1HO,50X,
     130HCRACK IS A CRACK IN TRANSITION,/1HO,43X,
     225HHALF FRONT       HALF BACK,38X,5HFRONT,9X,4HBACK)
 8003 FORMAT(1H ,12X,45HBLOCK   STEP        CYCLES        CRACK LENGTH    ,
     160HCRACK LENGTH     KMAX-FRONT      KMAX-BACK       GROWTH RATE    ,
     211HGROWTH RATE,/1H ,46X,4H(IN),11X,4H(IN),6X,13H(KSI ROOT-IN),
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     32X,13H(KSI ROOT-IN),4X,10H(IN/CYCLE),5X,10H(IN/CYCLE),//)
8004 FORMAT(10H           ,I6,3X,I4,7(3X,1PE12.3))
8005 FORMAT(10H           ,I6,3X,I4,7(3X,1PE12.3))
     END
```

```
      SUBROUTINE TCGROW
      COMMON X(12,25),Y(12,25),TABLE(12,25,25),FIXED,KCPRF,KAPRF,
     1 PRDDFX,NKTMX,NOX(12),NOY(12),NTAB(10),IPLOT,IFAIL,CUMSUM,PCYC(2)
      COMMON A,AP(2),ALIM,AOL(2),C,CB,CLIM,CR(2,10,10),CO,CUME,
     1 CUMELM,C1B1,D(2,10,10),DK,DKE,DXDX,FA,FC,H,INC,KCL,KC1,KOL,
     2 KOA,KOC,KCRA,KCRC,KMAX,OA,OC,PI,R,RAD,RE,RYOL(2),RUL(2),
     3 SIG,SIGLM,SIGY,SIGYS(10),SMIN(422),SMAX(422),TH,
     4 UNIT(422),W,DCTMP,DELTMP,DXTMP,
     5 ALOWN,BLOCK,FLAG1,I,ICD(2),ICK(2),ICR(2),IBLOCK,IFIRST,IPRN(4),
     6 ISTEP,ITRANS,J,KTYPE(2),NC,NEQ(10),NR,NRET(10),TYPE,TITL
      INTEGER ALOWN,BLOCK,FLAG1,TYPE(422),TITL(20)
      REAL KCL,KC1,KOL,KOA(10),KOC(10),KCRA(10),KCRC(10),KMAX
      REAL INC,KC,KAPRF,KCPRF
      IFIRST=1
 1000 J=TYPE(I)
 1025 DEL=INC*C
      IF (NRET(J)) 1050,1050,1030
 1030 IF (ABS(RYOL(1))-.0001) 1050,1050,1038
 1038 IF (DEL-.1*RYOL(1)) 1050,1050,1040
 1040 DEL=.1*RYOL(1)
 1050 C=C+DEL
      SIGY=SIGYS(J)
      IF (FLAG1) 1130,1100,1130
 1100 R=0
      SIG=SIGLM
      CALL KANAL
      IF (SIGLM*FC-KCRC(J)) 1130,1130,1120
 1120 FLAG1=1
      CLIM=C
      IBLOCK=BLOCK
      ISTEP=I
      CUMELM=CUME
 1130 C=C-DEL/2
      SIG=SMAX(I)
      R=SMIN(I)/SMAX(I)
      CALL KANAL
      C=C-DEL/2
      KC=FC*SIG
      DKC=(1-R)*KC
      IF (KC-KCRC(J)) 1160,1160,1153
 1153 IF (FLAG1) 1155,1155,1154
 1154 WRITE(6,6019) IBLOCK,ISTEP,CUMELM
 1155 WRITE (6,6003) BLOCK,I,CUME
      IFAIL=2
      CUMSUM=CUMSUM+CUME
      ICR(1)=-1
      RETURN
 1160 IF (KOC(J)-DKC) 1190,1170,1170
 1170 DCDX=0
      GO TO 1180
 1190 KMAX=KC
      DK=DKC
      NC=1
      CALL DAMAGE
      DCDX=DXDX
 1180 IF (IPRN(2)-IPRN(4)) 1191,1195,1195
 1191 IF (IPRN(2)) 1192,1193,1193
 1192 WRITE(6,8002) NR,TITL
      WRITE(6,8003)
      IPRN(2)=0
```

```
      DELTMP=0.
      DXTMP=0.
 1193 IF (IFIRST-1) 1195,1194,1195
 1194 IFIRST=0
      IPRN(2)=IPRN(2)+1
      WRITE(6,8004) BLOCK,I,CUME,C,KC,DCDX
 1195 CONTINUE
      IF (DCDX) 1200,5000,1210
 1200 ICR(1)=-1
      WRITE(6,6100)
      CUMSUM=CUMSUM+CUME
      RETURN
 1210 AVAIL=UNIT(I)-CUME
      IF (ALOWN-1) 1230,1220,1230
 1220 DX=1
      DEL=DCDX
      GO TO 1280
 1230 DX=DEL/DCDX
      IF (DX-AVAIL) 1280,1280,1270
 1270 DELTMP=DELTMP+AVAIL*DCDX
      IF (C) 1271,1272,1271
 1271 IF (DELTMP/C-1.E-4) 5000,5000,1272
 1272 C=C+DELTMP
      DELTMP=0.
      GO TO 5000
 1280 DELTMP=DELTMP+DEL
      IF (C) 1281,1282,1281
 1281 IF (DELTMP/C-1.E-4) 1284,1284,1282
 1282 C=C+DELTMP
      DELTMP=0.
 1284 DXTMP=DXTMP+DX
      IF (IPLOT.NE.2) GO TO 1300
      CUMTMP=CUMSUM+CUME
      IF (CUMTMP.LT.PCYC(2)) GO TO 1300
      WRITE(7,7000) A,C,CUMTMP
      PCYC(2)=PCYC(2)+PCYC(1)
 1300 IF (CUME) 1285,1286,1285
 1285 IF (DXTMP/CUME-1.E-4) 1025,1025,1286
 1286 CUME=CUME+DXTMP
      DXTMP=0.
      GO TO 1025
 5000 CONTINUE
      CUMSUM=CUMSUM+UNIT(I)
      CUME=UNIT(I)
      IF (IPLOT.NE.2) GO TO 5005
      IF (CUMSUM.LT.PCYC(2)) GO TO 5005
      WRITE(7,7000) A,C,CUMSUM
      PCYC(2)=PCYC(2)+PCYC(1)
 5005 IF (IPRN(2)-IPRN(4)) 5010,5020,5020
 5010 IPRN(2)=IPRN(2)+1
      WRITE(6,8005) BLOCK,I,CUME,C,KC,DCDX
      IF (IPLOT.NE.1) GO TO 5020
      WRITE(7,7000) A,C,CUMSUM
 5020 CONTINUE
      RETURN
 6003 FORMAT(47H0CRITICAL K AT SURFACE HAS BEEN EXCEEDED IN THE,I6,
     1 14H BLOCK AND THE,I4,11H STEP AFTER,1PE12.3,7H CYCLES )
 6019 FORMAT(35H0LIMIT LOAD FRACTURE OCCURS IN THE ,I6,7H BLOCK ,
     1 I4,12H STEP AFTER ,1PE12.3,7H CYCLES)
 6100 FORMAT(1H0,29HCRACK GROWTH RATE IS NEGATIVE,/1H ,
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```
     1 46HACCEPTABLE END OF LIFE IF FORMAN EQUATION USED)
 7000 FORMAT(4HDATA,1P3E12.3)
 8002 FORMAT(5H1RUN ,I4,5X,20A4,/1H0,50X,24HCRACK IS A THROUGH CRACK,
     1/1H0,46X,4HHALF,25X,5HCRACK)
 8003 FORMAT(1H ,12X,45HBLOCK  STEP       CYCLES      CRACK LENGTH    ,
     14X,4HKMAX,7X,11HGROWTH RATE,/1H ,46X,4H(IN),6X,13H(KSI ROOT-IN),
     24X,10H(IN/CYCLE),//)
 8004 FORMAT(10H                    ,I6,3X,I4,7(3X,1PE12.3))
 8005 FORMAT(10H                    ,I6,3X,I4,7(3X,1PE12.3))
      END
```

```
      SUBROUTINE DAMAGE
      COMMON X(12,25),Y(12,25),TABLF(12,25,25),FIXED,KCPRF,KAPRF,
     1 PRCCFX,NKTMX,NOX(12),NOY(12),NTAB(10),IPLOT,IFAIL,CUMSUM,PCYC(2)
      COMMON A,AP(2),ALIM,AOL(2),C,CB,CLIM,CR(2,10,10),CO,CUME,
     1 CUMELM,C1B1,D(2,10,10),DK,DKE,DXDX,FA,FC,H,INC,KCL,KC1,KOL,
     2 KOA,KOC,KCRA,KCRC,KMAX,OA,OC,PI,R,RAD,RE,RYCL(2),ROL(2),
     3 SIG,SIGLM,SIGY,SIGYS(10),SMIN(422),SMAX(422),TH,
     4 UNIT(422),W,DCTMP,DELTMP,DXTMP,
     5 ALOWN,BLOCK,FLAG1,I,ICD(2),ICK(2),ICR(2),IBLOCK,IFIRST,IPRN(4),
     6 ISTEP,ITRANS,J,KTYPE(2),NC,NEQ(10),NR,NRET(10),TYPE,TITL
      INTEGER ALOWN,BLOCK,FLAG1,TYPE(422),TITL(20)
      REAL KCL,KC1,KOL,KCA(10),KOC(10),KCRA(10),KCRC(10),KMAX,INC
      REAL KO,KCR,KCPRF,KAPRF
      RE=R
      DKE=(1.-RE)*KMAX
      IF (NEQ(J)) 700,700,10
   10 IF (NEQ(J)-4) 20,20,700
   20 J1=NEQ(J)
      GO TO (30,200,300,400), J1
C
C     COLLIPRIEST-EHRET EQUATION
C
   30 CD=D(NC,1,J)
      PN=D(NC,2,J)
      KO=D(NC,4,J)
      KCR=D(NC,3,J)
      IF (NRET(J)) 80,90,80
   80 CALL RETARD             TEST = DKE - (1.-RE)*KCR
   90 CC1=ALOG(KCR/KO)         IF (TEST.GT.0.) GO TO 340
      CC2=CC1*PN/2.
      CC1=PN/2.
      CC1=(KCR*KO)**CC1
      CC1=CD*CC1
      T1=(1.-RE)*KCR*KO
      T1=(DKE**2)/T1
      T1=ALOG(T1)
      T2=(1.-R)*KCR/KO          R=RE
      T2=ALOG(T2)
      T1=T1/T2
      T3=(1.+T1)/(1.-T1)
      T2=.5*ALOG(T3)
      T1=CC2*T2
      T2=EXP(T1)
      DXDX=CC1*T2
      GO TO 600
C
C     PARIS EQUATION
C
  200 IF (NC-2) 220,210,220
  210 CD=D(2,1,J)
      PN=D(2,2,J)
      GO TO 250
  220 CD=D(1,1,J)
      PN=D(1,2,J)
  250 IF (NRET(J)) 260,270,260
  260 CALL RETARD
  270 DXDX=-1
      IF (DKE-KOC(J)) 271,275,275
  271 IF (NC-1) 275,272,275
  272 DXDX=0
```

```
      GO TO 600
  275 IF (DKE-KOA(J)) 276,278,278
  276 IF (NC-2) 278,277,278
  277 DXDX=0
      GO TO 600
  278 DXDX=CD*DKE**PN
      GO TO 600
C
C     FORMAN EQUATION
C
  300 DXDX=-1
      IF (DKE-KOC(J)) 310,330,330
  310 IF (NC-1) 330,320,330
  320 DXDX=0
      GO TO 600
  330 IF (DKE-KOA(J)) 340,360,360
  340 IF (NC-2) 360,350,360
  350 DXDX=0
      GO TO 600
  360 IF ((1.-RE)*D(NC,3,J)-DKE) 370,370,380
  370 WRITE(6,6001)
      GO TO 600
  380 DXDX = D(NC,1,J)*DKE**D(NC,2,J)
      DXDX=DXDX/((1.-RE)*D(NC,3,J)-DKE)
      GO TO 600
C
C     INTERPOLATION MODEL
C
  400 NT=NTAB(J)
      IF (NC.EQ.1) GO TO 402
      NT=NT+1
  402 IF (NRET(J)) 420,420,410
  410 CALL RETARD
  420 IF (NT.LT.13) GO TO 430
      WRITE(6,6002)
      STOP
  430 CALL INTP(NT,DKE,RE,2,DXDX)
      RETURN
  600 RETURN
  700 WRITE (6,1000) NEQ(J)
      STOP
 1000 FORMAT (10HONEQ(J) = ,I3,13H OUT OF RANGE)
 6001 FORMAT(39HOCRACK GROWTH RATE HAS GONE TO INFINITY)
 6002 FORMAT(1HO,'NT IS GREATER THAN 12')
      END
```

```
      SUBROUTINE RETARD
      COMMON XX(12,25),YY(12,25),TABLE(12,25,25),FIXED,KCPRF,KAPRF,
     1 PROOFX,NKTMX,NOX(12),NOY(12),NTAB(10),IPLOT,IFAIL,CUMSUM,PCYC(2)
      COMMON A,AP(2),ALIM,AOL(2),C,CB,CLIM,CR(2,10,10),CO,CUMF,
     1 CUMELM,C1B1,D(2,10,10),DK,DKE,DXDX,FA,FC,H,INC,KCL,KC1,KOL,
     2 KOA,KOC,KCRA,KCRC,KMAX,OA,OC,PI,R,RAD,RE,RYOL(2),ROL(2),
     3 SIG,SIGLM,SIGY,SIGYS(10),SMIN(422),SMAX(422),TH,
     4 UNIT(422),W,DCTMP,DELTMP,DXTMP,
     5 ALOWN,BLOCK,FLAG1,I,ICD(2),ICK(2),ICR(2),IBLOCK,IFIRST,IPRN(4),
     6 ISTEP,ITRANS,J,KTYPE(2),NC,NEQ(10),NR,NRET(10),TYPF,TITL
      INTEGER ALOWN,BLOCK,FLAG1,TYPE(422),TITL(20)
      REAL KCL,KC1,KOL,KOA(10),KOC(10),KCRA(10),KCRC(10),KMAX,INC
      REAL KAP,KMINE,KC2,KMAXE,KCPRF,KAPRF
      PZ = CR(NC,1,J)
      IF (NRET(J)) 500,500,10
   10 IF (NRET(J)-3) 20,20,500
   20 J1=NRET(J)
      IF (NC-1) 22,21,22
   21 X=C
      GO TO 23
   22 X=A
   23 CONTINUE
      GO TO (30,200,300), J1
C
C     WILLENBORG MODEL
C
   30 RY=(KMAX/SIGY)**2
      R1=CR(NC,1,J)*2.*PI
      R1=1./R1
      RY=RY*R1
      IF (RY-AP(NC)+X) 50,40,40
   40 AP(NC)=X+RY
      RYOL(NC)=RY
   50 KAP=2*PI*(AP(NC)-X)
      KAP=SQRT(KAP)*SIGY
      KMAXE=2*KMAX-KAP
      KMINE=(1+R)*KMAX - KAP
      IF (KMINE) 60,60,70
   60 KMINE=0
   70 IF (KMAXE) 80,80,90
   80 KMAXE=0
   90 DKE=KMAXE-KMINE
      RE=KMINE/KMAXE
      GO TO 430
C
C     WHEELER MODEL
C
  200 RY=(KMAX/SIGY)**2
      R1=CR(NC,1,J)*2.*PI
      R1=1./R1
      RY=RY*R1
      IF (RY-AP(NC)+X) 220,210,210
  210 AP(NC)=X+RY
      RYOL(NC)=RY
  220 DKE=RY/(AP(NC)-X)
      DKE=DKE**CR(NC,2,J)
      DKE=DKE*(1.-R)*KMAX
      RE=R
      GO TO 430
C
```

```
C     GRUMMAN CLOSURE MODEL
C
  300 ALOWN=0
      PZ=CR(NC,1,J)
      CFM1 = CR(NC,2,J)
      CFO = CR(NC,3,J)
      P = CR(NC,4,J)
      NSAT = CR(NC,5,J)
      GAM1 = CR(NC,6,J)
      BG = CR(NC,7,J)
      RY=(KMAX/SIGY)**2
      R1=PZ*2*PI
      R1=1./R1
      RY=R1*RY
      CF2=CFM1+(CFO-CFM1)*(1+R)**P
      KC2=CF2*KMAX
      IF (R*KMAX-ROL(NC)*KOL) 310,320,320
  310 ROL(NC)=(R*KMAX)/KOL
      CF1=CFM1+(CFO-CFM1)*(1+ROL(NC))**P
      KC1=CF1*KOL
      AOL(NC)=X
  320 IF (KMAX-KCL) 330,330,340
  330 DKE=0
      RE=0
      GO TO 430
  340 IF (KC2-KCL) 350,350,380
  350 IF (AP(NC)-X-RY) 360,370,370
  360 KCL=KC1-(KC1-KC2)*((X-AOL(NC))/RYOL(NC))**BG
      GO TO 400
  370 KCL=KC2
      GO TO 400
  380 IF (CUME+1-NSAT) 390,370,370
  390 GAM=GAM1+(1-GAM1)*CUME/(NSAT-1)
      KCL=GAM*KMAX
      ALOWN=1
  400 DKE=KMAX-KCL
      RE=KCL/KMAX
      IF (AP(NC)-X-RY) 410,420,420
  410 IF (KMAX-KOL) 430,430,420
  420 KC1=KC2
      KOL=KMAX
      ROL(NC)=R
      AOL(NC)=X
      RYOL(NC)=RY
      AP(NC)=AOL(NC)+RYOL(NC)
  430 RETURN
  500 WRITE(6,1000) NRET(J)
 1000 FORMAT(11HONRET(J) = ,I3,13H OUT OF RANGE)
      STOP
      END
```

```
      SUBROUTINE INTP(NT,XT,YT,INTPEQ,F)
      COMMON X(12,25),Y(12,25),TABLE(12,25,25),FIXED,KCPRF,KAPRF,
     1 PROOFX,NKTMX,NOX(12),NOY(12),NTAB(10),IPLOT,IFAIL,CUMSUM,PCYC(2)
      REAL KCPRF,KAPRF
      NEND=0
      NUMX=NOX(NT)
      NUMY=NOY(NT)
      IF (X(NT,1).GT.XT) GO TO 5
      IF (X(NT,NUMX).GE.XT) GO TO 10
    5 WRITE(6,6010) XT,NT
      NEND=1
   10 IF (Y(NT,1).GT.YT) GO TO 15
      IF (Y(NT,NUMY).GE.YT) GO TO 20
   15 WRITE(6,6020) YT,NT
      NEND=1
   20 IF (NEND) 30,40,30
   30 STOP
   40 DO 50 IJ=2,NUMX
      IF (XT.LT.X(NT,IJ)) GO TO 60
   50 CONTINUE
   60 NX=IJ
      DO 70 IJ=2,NUMY
      IF (YT.LT.Y(NT,IJ)) GO TO 80
   70  CONTINUE
   80 NY=IJ
      IF (INTPEQ.EQ.1) GO TO 100
      IF (INTPEQ.EQ.2) GO TO 200
      WRITE(6,6030)
      STOP
C
C     FOUR POINT LINEAR BIVARIATE INTERPOLATION
C
  100 NXM1=NX-1
      NYM1=NY-1
      P=X(NT,NX)-X(NT,NXM1)
      P=(XT-X(NT,NXM1))/P
      Q=Y(NT,NY)-Y(NT,NYM1)
      Q=(YT-Y(NT,NYM1))/Q
      F00=TABLE(NT,NXM1,NYM1)
      F10=TABLE(NT,NX,NYM1)
      F01=TABLE(NT,NXM1,NY)
      F11=TABLE(NT,NX,NY)
      F=(1.-P)*(1.-Q)*F00 + P*(1.-Q)*F10
      F=F + Q*(1.-P)*F01 + P*Q*F11
      RETURN
C
C     FOUR POINT LOG-LINEAR BIVARIATE INTERPOLATION
C
  200 NXM1=NX-1
      NYM1=NY-1
      P=ALOG(XT/X(NT,NXM1))
      P=P/ALOG(X(NT,NX)/X(NT,NXM1))
      Q=Y(NT,NY)-Y(NT,NYM1)
      Q=(YT-Y(NT,NYM1))/Q
      F00=ALOG(TABLE(NT,NXM1,NYM1))
      F10=ALOG(TABLE(NT,NX,NYM1))
      F01=ALOG(TABLE(NT,NXM1,NY))
      F11=ALOG(TABLE(NT,NX,NY))
      F=(1.-P)*(1.-Q)*F00 + P*(1.-Q)*F10
      F=F + Q*(1.-P)*F01 + P*Q*F11
```

```
      F=EXP(F)
      RETURN
 6010 FORMAT(1H0, 4HX = ,1PE12.3,26H IS OUT OF RANGE OF TABLE ,I4)
 6020 FORMAT(1H0, 4HY = ,1PE12.3,26H IS OUT OF RANGE OF TABLE ,I4)
 6030 FORMAT(1H0,21HERROR IN CALL TO INTP)
      END
```

```
      SUBROUTINE KANAL
      COMMON X(12,25),Y(12,25),TABLE(12,25,25),FIXED,KCPRF,KAPRF,
     1 PROCEX,NKTMX,NDX(12),NDY(12),NTAB(10),IPLOT,IFAIL,CUMSUM,PCYC(2)
      COMMON A,AP(2),ALIM,AOL(2),C,CB,CLIM,CR(2,10,10),CO,CUME,
     1 CUMFLM,C1B1,D(2,10,10),DK,DKE,DXDX,FA,FC,H,INC,KCL,KC1,KOL,
     2 KOA,KOC,KCRA,KCRC,KMAX,OA,OC,PI,R,RAD,RE,RYCL(2),ROL(2),
     3 SIG,SIGLM,SIGY,SIGYS(10),SMIN(422),SMAX(422),TH,
     4 UNIT(422),W,DCTMP,DELTMP,DXTMP,
     5 ALOWN,BLOCK,FLAG1,I,ICD(2),ICK(2),ICR(2),IBLOCK,IFIRST,IPRN(4),
     6 ISTEP,ITRANS,J,KTYPE(2),NC,NFO(10),NR,NRET(10),TYPE,TITL
      INTEGER ALOWN,BLOCK,FLAG1,TYPE(422),TITL(20)
      REAL KCL,KC1,KOL,KOA(10),KOC(10),KCRA(10),KCRC(10),KMAX,INC
      REAL KCPRF,KAPRF
C
      KT=KTYPE(1)
      GO TO (1000,2000,3000), KT
C
C     PART THROUGH CRACK
C
 1000 KT=KTYPE(2)
      GO TO (1020,1040,1060,1080,1100,1120,1140,1160,1180,1200,1220,
     1 1240,1260,1280,1300,1320,1340), KT
C
C     PTC 01 - CENTER CRACK
C
 1020 IF (C) 1024,1022,1024
 1022 C=1.E-20
 1024 B=AMIN1(A,C)
      B=SQRT(PI*B)
      AOVC=A/C
      FSUR=FUNP1(AOVC,2)
      FDEP=FUNP1(AOVC,1)
      FC=B*FSUR/SQRT(COS(PI*C/W))
      W1=A/TH
      W2=.089*W1-.2315*W1**2-.3673*W1**3+5.28*W1**4
      W2=W2-9.11*W1**5+5.233*W1**6
      W1=A/(2.*C)
      FA=1.109-9.142*W1+41.56*W1**2-86.55*W1**3+65.5*W1**4
      PHI2=(W2*FA/.502) + 1.
      PHI2=PHI2*(1. + .12*(1.-W1)**2)
      FA=B*FDEP*PHI2
      GO TO 4000
C
C     PTC 02 - NO COMPACT CRACK FOR PART-THROUGH
C
 1040 WRITE(6,6002)
      STOP
C
C     PTC 03 - SINGLE CORNER CRACK AT HOLE
C
 1060 CONTINUE
      B=AMIN1(A,C)
      FA=SQRT(PI*B)
      FB=1.2133-2.205*(C/(C+RAD))+.6451*(C/(C+RAD))**2
      FB=EXP(FB)
      FS1=1./COS(PI*RAD/W)
      FA=FA*SQRT(FS1)*FB
      AOVC=A/C
      FS1=FUNP1(AOVC,1)
      FS2=FUNP1(AOVC,2)
```

```
      FA=FA*FS1
      FC=PI*(C+2.*RAD)/(2.*(W-C))
      FC=SQRT(1./COS(FC))*FB*SQRT(PI*B)*FS2
      GO TO 4000
C
C     PTC 04 - DOUBLE CORNER CRACK AT HOLE
C
 1080 CONTINUE
      B=AMIN1(A,C)
      S=C/(C+RAD)
      FB=EXP(1.2133-2.086*S+.8727*S*S)
      FA=SQRT(1./COS(PI*RAD/W))*FB
      AOVC=A/C
      FS1=FUNP1(AOVC,1)
      FS2=FUNP1(AOVC,2)
      FA=FA*FS1*SQRT(PI*B)
      FC=SQRT(PI*B)*SQRT(1./COS(PI*(C+RAD)/W))*FB*FS2
      GO TO 4000
C
C     PTC 05 - SINGLE INTERNAL CRACK AT HOLE
C
 1100 CONTINUE
      B=AMIN1(A,C)
      FC=SQRT(PI*B)/1.122
      FS6=C/(C+RAD)
      FB=EXP(1.2133-2.205*FS6+.6451*FS6**2)
      FC=SQRT(1./COS(PI*(C+2.*RAD)/(2.*(W-C))))*FB*FC
      AOVC=A/C
      FS6=FUNP1(AOVC,1)
      FS5=FUNP1(AOVC,2)
      FC=FC*FS6
      FA=SQRT(PI*B)/1.122
      FA=FB*FA*FS5*SQRT(1./COS(PI*RAD/W))
      GO TO 4000
C
C     PTC 06 - DOUBLE INTERNAL CRACK AT HOLE
C
 1120 CONTINUE
      B=AMIN1(A,C)
      FC=SQRT(PI*B)/1.122
      FA=FC
      S=C/(RAD+C)
      FB=EXP(1.2133-2.086*S+.8727*S*S)
      FC=SQRT(1./COS(PI*(C+RAD)/W))*FB*FC
      AOVC=A/C
      FS6=FUNP1(AOVC,1)
      FS5=FUNP1(AOVC,2)
      FC=FC*FS6
      FA=FB*FA*FS5*SQRT(1./COS(PI*RAD/W))
      GO TO 4000
C
C     PTC 07 - INTERPOLATION MODEL - PART-THROUGH CRACK
C
 1140 FA=SQRT(PI*A)
      FC=FA
      NT=0
 1142 NT=NT+1
      CALL INTP(NT,C,A,1,FCC)
      NT=NT+1
      CALL INTP(NT,C,A,1,FAA)
```

```
      FC=FC*FCC
      FA=FA*FAA
      IF(NT-NKTMX*2) 1142,4000,4000
C
C     PTC 08 - PIN LOADED LUG, SINGLE CORNER CRACK
C
 1160 Z=(C+2.*RAD)/2.
      E=C/2.
      B=W/2.
      BP=B-E
      FS1=2.*Z/H
      FS2=Z/BP
      PHCP=FUNT1(FS2)
      PHCP=PHCP/SQRT(1.-FS2)
      PHHP=1.-.08*FS1+2.69*FS1**2-.99*FS1**3
      PHWP=1.-.5*FS2+.957*FS2**2-.16*FS2**3
      PHWP=PHWP/SQRT(1.-FS2)
      PHP=(PHCP+PHHP*PHWP)/2.
      PHP=PHP*SQRT(1.+(Z+E)/(Z-E)/9.)
      PHCS=FUNT2(FS2)
      PHCS=PHCS/SQRT(1.-FS2)
      PHSS=FUNT3(FS1)
      PHSS=PHSS*SQRT(1./COS(PI*Z/(2.*BP)))
      S=C/(C+RAD)
      FB=EXP(1.2133-2.205*S+.6451*S*S)
      PHS=(PHCS+PHSS)*FB/2.
      FCP=PHS*SQRT(PI*C)/(2.*W*TH)
      FC=FCP+PHP*SQRT((Z-E)/(Z+E))/SQRT(PI*Z)/(2.*TH)
      D1=AMIN1(A,C)
      ADVC=A/C
      FS2=FUNP1(ADVC,2)
      FS4=SQRT(PI*D1)/SQRT(PI*C)
      FC=FC*FS2*FS4
      Z=(C+2.*RAD)/2.
      E=C/2.
      B=W/2.
      BP=B-E
      FS1=2.*Z/H
      FS2=RAD/B
      PHCP=FUNT1(FS2)
      PHCP=PHCP/SQRT(1.-FS2)
      PHHP=1.08*FS1+2.69*FS1**2-.99*FS1**3
      PHWP=1.-.5*FS2+.957*FS2**2-.16*FS2**3
      PHWP=PHWP/SQRT(1.-FS2)
      PHP=(PHCP+PHHP*PHWP)/2.
      PHCS=FUNT2(FS2)
      PHCS=PHCS/SQRT(1.-FS2)
      PHSS=FUNT3(FS1)
      PHSS=PHSS*SQRT(1./COS(PI*RAD/(2.*B)))
      S=C/(C+RAD)
      FB=EXP(1.2133-2.205*S+.6451*S*S)
      PHS=(PHCS+PHSS)*FB/2.
      FCP=PHS*SQRT(PI*C)/(2.*W*TH)
      FCP=FCP+PHP*SQRT((Z-E)/(Z+E))/SQRT(PI*Z)/(2.*TH)
      FO=FCP*SQRT(1.+(Z+E)/(Z-E)/9.)
      FA=FUNP1(ADVC,1)
      FA=FO*FA*FS4
      GO TO 4000
C
C     PTC 09 - PIN LOADED LUG, TWO CORNER CRACKS
```

```
C
 1180 B=W/2.
      Z=RAD+C
      PHCP=FUNT1(Z/B)
      FS1=2.*Z/W
      FS2=2.*Z/H
      PHCP=PHCP/SQRT(1.-FS1)
      PHWP=1.-.5*FS1+.957*FS1**2-.16*FS1**3
      PHWP=PHWP/SQRT(1.-FS1)
      PHHP=1.-.08*FS2+2.69*FS2**2-.91*FS2**3
      PHP=(PHCP+PHWP*PHHP)/2.
      PHCS=FUNT2(Z/B)
      PHCS=PHCS/SQRT(1.-FS1)
      PHSS=FUNT3(FS2)
      PHSS=PHSS*SQRT(1./COS(PI*Z/W))
      S=C/(RAD+C)
      FB=EXP(1.2133-2.086*S+.8727*S*S)
      PHS=(PHCS+PHSS)*FB/2.
      FC=1.05*PHP/(2.*TH*SQRT(PI*Z))
      FC=FC+PHS*SQRT(PI*C)/(2.*W*TH)
      ADVC=A/C
      DI=AMIN1(A,C)
      FS2=FUNP1(ADVC,2)
      FS4=SQRT(PI*DI)/SQRT(PI*C)
      FC=FC*FS2*FS4
C
      B=W/2.
      Z=RAD+C
      FS1=RAD/B
      PHCP=FUNT1(FS1)
      FS2=2.*Z/H
      PHCP=PHCP/SQRT(1.-FS1)
      PHWP=1.-.5*FS1+.957*FS1**2-.16*FS1**3
      PHWP=PHWP/SQRT(1.-FS1)
      PHHP=1.-.08*FS2+2.69*FS2**2-.91*FS2**3
      PHP=(PHCP+PHWP*PHHP)/2.
      PHCS=FUNT2(FS1)
      PHCS=PHCS/SQRT(1.-FS1)
      PHSS=FUNT3(FS2)
      PHSS=PHSS*SQRT(1./COS(PI*RAD/W))
      S=C/(RAD+C)
      FB=EXP(1.2133-2.086*S+.8727*S*S)
      PHS=(PHCS+PHSS)*FB/2.
      FQ=1.05*PHP/(2.*TH*SQRT(PI*Z))
      FQ=FQ+PHS*SQRT(PI*C)/(2.*W*TH)
      FA=FUNP1(ADVC,1)
      FA=FQ*FA*FS4
      GO TO 4000
C
C     PTC 10 - PIN LOADED LUG, SINGLE INTERNAL CRACK
C
 1200 Z=(C+2.*RAD)/2.
      E=C/2.
      B=W/2.
      BP=B-E
      FS1=2.*Z/H
      FS2=Z/BP
      PHCP=FUNT1(FS2)
      PHCP=PHCP/SQRT(1.-FS2)
      PHHP=1.-.08*FS1+2.69*FS1**2-.99*FS1**3
```

```
      PHWP=1.-.5*FS2+.957*FS2**2-.16*FS2**3
      PHWP=PHWP/SQRT(1.-FS2)
      PHP=(PHCP+PHHP*PHWP)/2.
      PHP=PHP*SQRT(1.+(Z+E)/(Z-E)/9.)
      PHCS=FUNT2(FS2)
      PHCS=PHCS/SQRT(1.-FS2)
      PHSS=FUNT3(FS1)
      PHSS=PHSS*SQRT(1./COS(PI*Z/(2.*BP)))
      S=C/(C+RAD)
      FB=EXP(1.2133-2.205*S+.6451*S*S)
      PHS=(PHCS+PHSS)*FB/2.
      FCP=PHS*SQRT(PI*C)/(2.*W*TH)
      FC=FCP+PHP*SQRT((Z-E)/(Z+E))/SQRT(PI*Z)/(2.*TH)
      D1=AMIN1(A,C)
      ADVC=A/C
      FS4=SQRT(PI*D1)/SQRT(PI*C)
      FA=FUNP1(ADVC,1)
      FC=FC*FA/1.122*FS4
      Z=(C+2.*RAD)/2.
      E=C/2.
      B=W/2.
      BP=B-E
      FS1=2.*Z/H
      FS2=RAD/B
      PHCP=FUNT1(FS2)
      PHCP=PHCP/SQRT(1.-FS2)
      PHHP=1.08*FS1+2.69*FS1**2-.99*FS1**3
      PHWP=1.-.5*FS2+.967*FS2**2-.16*FS2**3
      PHWP=PHWP/SQRT(1.-FS2)
      PHP=(PHCP+PHHP*PHWP)/2.
      PHCS=FUNT2(FS2)
      PHCS=PHCS/SQRT(1.-FS2)
      PHSS=FUNT3(FS1)
      PHSS=PHSS*SQRT(1./COS(PI*RAD/(2.*B)))
      S=C/(C+RAD)
      FB=EXP(1.2133-2.205*S+.6451*S*S)
      PHS=(PHCS+PHSS)*FB/2.
      FCP=PHS*SQRT(PI*C)/(2.*W*TH)
      FCP=FCP+PHP*SQRT((Z-E)/(Z+E))/SQRT(PI*Z)/(2.*TH)
      FC=FCP*SQRT(1.+(Z+E)/(Z-E)/9.)
      FA=FUNP1(ADVC,2)
      FA=FC*FA/1.122*FS4
      GO TO 4000
C
C     PTC 11 - PIN LOADED LUG, TWO INTERNAL CRACKS
C
 1220 B=W/2.
      Z=RAD+C
      PHCP=FUNT1(Z/B)
      FS1=2.*Z/W
      FS2=2.*Z/H
      PHCP=PHCP/SQRT(1.-FS1)
      PHWP=1.-.5*FS1+.967*FS1**2-.16*FS1**3
      PHWP=PHWP/SQRT(1.-FS1)
      PHHP=1.-.08*FS2+2.69*FS2**2-.91*FS2**3
      PHP=(PHCP+PHWP*PHHP)/2.
      PHCS=FUNT2(Z/B)
      PHCS=PHCS/SQRT(1.-FS1)
      PHSS=FUNT3(FS2)
      PHSS=PHSS*SQRT(1./COS(PI*Z/W))
```

```
      S=C/(RAD+C)
      FB=EXP(1.2133-2.086*S+.8727*S*S)
      PHS=(PHCS+PHSS)*FB/2.
      FC=1.05*PHP/(2.*TH*SQRT(PI*Z))
      FC=FC+PHS*SQRT(PI*C)/(2.*W*TH)
      D1=AMIN1(A,C)
      AOVC=A/C
      FS4=SQRT(PI*D1)/SQRT(PI*C)
      FA=FUNP1(AOVC,1)
      FC=FC*FA/1.122*FS4
C
      B=W/2.
      Z=RAD+C
      FS1=RAD/B
      PHCP=FUNT1(FS1)
      FS2=2.*Z/H
      PHCP=PHCP/SQRT(1.-FS1)
      PHWP=1.-.5*FS1+.957*FS1**2-.16*FS1**3
      PHWP=PHWP/SQRT(1.-FS1)
      PHHP=1.-.08*FS2+2.69*FS2**2-.91*FS2**3
      PHP=(PHCP+PHWP*PHHP)/2.
      PHCS=FUNT2(FS1)
      PHCS=PHCS/SQRT(1.-FS1)
      PHSS=FUNT3(FS2)
      PHSS=PHSS*SQRT(1./COS(PI*RAD/W))
      S=C/(RAD+C)
      FB=EXP(1.2133-2.086*S+.8727*S*S)
      PHS=(PHCS+PHSS)*FB/2.
      FQ=1.05*PHP/(2.*TH*SQRT(PI*Z))
      FQ=FQ+PHS*SQRT(PI*C)/(2.*W*TH)
      FA=FUNP1(AOVC,2)
      FA=FQ*FA/1.122*FS4
      GO TO 4000
C
C     PTC 12 - SINGLE CORNER CRACK AT SINGLE NOTCH
C
 1240 B=H
      FS2=.752+2.02*((B+C)/W)+.37*(1.-SIN(PI*(B+C)/2./W))**3
      FW=FS2/COS(PI*(B+C)/2./W)/1.122
      FW=FW*SQRT(W*2./PI/(B+C)*TAN(PI*(B+C)/W/2.))
      FS1=RAD/B
      IF (FS1.LT. .01) GO TO 1242
      S=C/(B+C)
      FC =FUNT4(S,FS1)
      FC=FC*FW*SQRT(PI*C)
      GO TO 1244
 1242 FC=1.122*SQRT(B+C)*FW
 1244 AOVC=A/C
      D1=AMIN1(A,C)
      FC=FC*SQRT(PI*D1)/SQRT(PI*C)*FUNP1(AOVC,2)
C
      FS2=.752+2.02*(B/W)+.37*(1.-SIN(PI*B/W/2.))**3
      FW=FS2/COS(PI*B/W/2.)/1.122
      FW=FW*SQRT(W*2./PI/B*TAN(PI*B/W/2.))
      FS1=RAD/B
      IF (FS1.LT. .01) GO TO 1246
      S=C/B
      FQ =FUNT4(S,FS1)
      FQ=FQ*FW*SQRT(PI*C)
      GO TO 1248
```

```
 1246 FQ=1.122*SQRT(B)*FW
 1248 FA=FQ*SQRT(PI*D1)/SQRT(PI*C)*FUNPI(ADVC,1)
      GO TO 4000
C
C     PTC 13 - DOUBLE CORNER CRACK AT DOUBLE NOTCH
C
 1260 B=H
      FS2=.752+2.02*((B+C)/(W/2.))+.37*(1.-SIN(PI*(B+C)/W))**3
      FW=FS2/COS(PI*(B+C)/W)/1.122
      FW=FW*SQRT(W/PI/(B+C)*TAN(PI*(B+C)/W))
      FS1=RAD/B
      IF (FS1.LT. .01) GO TO 1262
      S=C/(B+C)
      FC =FUNT4(S,FS1)
      FC=FC*FW*SQRT(PI*C)
      GO TO 1264
 1262 FC=1.122*SQRT(B+C)*FW
 1264 ADVC=A/C
      D1=AMIN1(A,C)
      FW=(1.+.122*(COS(PI*(B+C)/W))**4)*COS(PI*(B+C)/W)
      FC=FC*FW/FS2
      FC=FC*SQRT(PI*D1)/SQRT(PI*C)*FUNPI(ADVC,2)
      FS2=.752+2.02*(B/(W/2.))+.37*(1.-SIN(PI*B/W))**3
      FW=FS2/COS(PI*B/W)/1.122
      FW=FW*SQRT(W/PI/B*TAN(PI*B/W))
      FS1=RAD/B
      IF (FS1.LT. .01) GO TO 1266
      S=C/B
      FQ =FUNT4(S,FS1)
      FQ=FQ*FW*SQRT(PI*C)
      GO TO 1268
 1266 FQ=1.122*SQRT(B)*FW
 1268 CONTINUE
      FW=(1.+.122*(COS(PI*B/W))**4)*COS(PI*B/W)
      FQ=FQ*FW/FS2
      FA=FQ*SQRT(PI*D1)/SQRT(PI*C)*FUNPI(ADVC,1)
      GO TO 4000
C
C     PTC 14 - SINGLE INTERNAL CRACK AT SINGLE NOTCH
C
 1280 B=H
      FS2=.752+2.02*((B+C)/W)+.37*(1.-SIN(PI*(B+C)/W/2.))**3
      FW=FS2/COS(PI*(B+C)/W/2.)/1.122
      FW=FW*SQRT(W*2./PI/(B+C)*TAN(PI*(B+C)/W/2.))
      FS1=RAD/B
      IF (FS1.LT. .01) GO TO 1282
      S=C/(B+C)
      FC =FUNT4(S,FS1)
      FC=FC*FW*SQRT(PI*C)
      GO TO 1284
 1282 FC=1.122*SQRT(B+C)*FW
 1284 ADVC=A/C
      D1=AMIN1(A,C)
      FC=FC*SQRT(PI*D1)/SQRT(PI*C)*FUNPI(ADVC,1)/1.122
C
      FS2=.752+2.02*(B/W)+.37*(1.-SIN(PI*B/W/2.))**3
      FW=FS2/COS(PI*B/W/2.)/1.122
      FW=FW*SQRT(W*2./PI/B*TAN(PI*B/W/2.))
      FS1=RAD/B
      IF (FS1.LT. .01) GO TO 1286
```

```
      S=C/B
      FQ =FUNT4(S,FS1)
      FQ=FQ*FW*SQRT(PI*C)
      GO TO 1288
 1286 FQ=1.122*SQRT(B)*FW
 1288 FA=FQ*SQRT(PI*D1)/SQRT(PI*C)*FUNP1(AOVC,2)/1.122
      GO TO 4000
C
C     PTC 15 - DOUBLE INTERNAL CRACK AT DOUBLE NOTCH
C
 1300 B=H
      FS2=.752+2.02*((B+C)/(W/2.))+.37*(1.-SIN(PI*(B+C)/W))**3
      FW=FS2/COS(PI*(B+C)/W)/1.122
      FW=FW*SQRT(W/PI/(B+C)*TAN(PI*(B+C)/W))
      FS1=RAD/B
      IF (FS1.LT. .01) GO TO 1302
      S=C/(B+C)
      FC =FUNT4(S,FS1)
      FC=FC*FW*SQRT(PI*C)
      GO TO 1304
 1302 FC=1.122*SQRT(B+C)*FW
 1304 AOVC=A/C
      D1=AMIN1(A,C)
      FW=(1.+.122*(COS(PI*(B+C)/W))**4)*COS(PI*(B+C)/W)
      FC=FC*FW/FS2
      FC=FC*SQRT(PI*D1)/SQRT(PI*C)*FUNP1(AOVC,1)/1.122
      FS2=.752+2.02*(B/(W/2.))+.37*(1.-SIN(PI*B/W))**3
      FW=FS2/COS(PI*B/W)/1.122
      FW=FW*SQRT(W/PI/B*TAN(PI*B/W))
      FS1=RAD/B
      IF (FS1.LT. .01) GO TO 1306
      S=C/B
      FQ =FUNT4(S,FS1)
      FQ=FQ*FW*SQRT(PI*C)
      GO TO 1308
 1306 FQ=1.122*SQRT(B)*FW
 1308 CONTINUE
      FW=(1.+.122*(COS(PI*B/W))**4)*COS(PI*B/W)
      FQ=FQ*FW/FS2
      FA=FQ*SQRT(PI*D1)/SQRT(PI*C)*FUNP1(AOVC,2)/1.122
      GO TO 4000
C
C     PTC 16 - CORNER CRACK OUT OF SHOULDER
C
 1320 B1=(W-H)/2.
      S1=C/(C+B1)
      FC=W/PI/(C+B1)*TAN(PI*(C+B1)/W)
      FC=SQRT(FC)
      FC=FC*(1.+.122*(COS(PI*(C+B1)/W))**4)/1.122
      FC=FC*SQRT(PI*C)*FUNT4(S1,C1B1)
      AOVC=A/C
      D1=AMIN1(A,C)
      FC=FC*SQRT(PI*D1)/SQRT(PI*C)*FUNP1(AOVC,2)
      B1=(W-H)/2.
      S1=C/B1
      FQ=W/PI/B1*TAN(PI*B1/W)
      FQ=FQ*(1.+.122*(COS(PI*B1/W))**4)
      FQ=FQ*SQRT(PI*C)*FUNT4(S1,C1B1)
      FA=FQ*SQRT(PI*D1)/SQRT(PI*C)*FUNP1(AOVC,1)
      GO TO 4000
```

```
C
C     PTC 17 - INTERNAL CRACK OUT OF SHOULDER
C
 1340 B1=(W-H)/2.
      S1=C/(C+B1)
      FC=W/PI/(C+B1)*TAN(PI*(C+B1)/W)
      FC=SQRT(FC)
      FC=FC*(1.+.122*(COS(PI*(C+B1)/W))**4)/1.122
      FC=FC*SQRT(PI*C)*FUNT4(S1,C1B1)
      ADVC=A/C
      D1=AMIN1(A,C)
      FC=FC*SQRT(PI*D1)/SQRT(PI*C)*FUNP1(ADVC,1)
      B1=(W-H)/2.
      S1=C/B1
      FQ=W/PI/B1*TAN(PI*B1/W)
      FQ=FQ*(1.+.122*(COS(PI*B1/W))**4)
      FQ=FQ*SQRT(PI*C)*FUNT4(S1,C1B1)
      FA=FQ*SQRT(PI*D1)/SQRT(PI*C)*FUNP1(ADVC,2)
      GO TO 4000
C
C     TRANSITION CRACK
C
 2000 CHOLD=C
      C=(C+CB)/2.
C
      KT=KTYPE(2)
      GO TO (3020,3040,3060,3080,3060,3080,3140,3160,3180,3160,3180,
     1 3240,3260,3240,3260,3320,3320), KT
C
 2100 C=CHOLD
      FA=1.-SQRT(1.-(CB/C)**2)
      FA=CB/(C*FA)
      FA=SQRT(FA)*FC
      GO TO 4000
C
C     THROUGH CRACK EQUATIONS
C
 3000 KT=KTYPE(2)
      GO TO (3020,3040,3060,3080,3060,3080,3140,3160,3180,3160,3180,
     1 3240,3260,3240,3260,3320,3320), KT
C
C     TC 01 - CENTER CRACKED PANEL
C
 3020 Z = PI*C
      Q= SQRT(Z)
      Z = COS(Z/W)
      Z = 1./Z
      Z = SQRT(Z)
      FC = Q*Z
      FA = 0
      IF (KTYPE(1).EQ.2) GO TO 2100
      GO TO 4000
C
C     TC 02 - COMPACT SPECIMEN
C
 3040 W1 = C/W
      W2 = SQRT(W1)
      FC = 29.6*W2 - 185.5*W1*W2
      W2 = W2*W1*W1
      FC = FC + 655.7*W2 - 1017.0*W2*W1
```

```
      W2 = W2*W1*W1
      FC = FC + 638.9 * W2
      FC = FC/TH
      FC = FC/SQRT(W)
      FA = 0
      IF (KTYPE(1).EQ.2) GO TO 2100
      GO TO 4000
C
C     TC 03,05 - SINGLE THROUGH CRACK AT HOLE
C
 3060 S=C/(RAD+C)
      FB=EXP(1.2133-2.205*S+.6451*S*S)
      FC=COS((C+2.*RAD)*PI/(2.*(W-C)))
      FC=SQRT(1./FC)
      FC=FC*SQRT(PI*C)*FB
      FA=0.
      IF (KTYPE(1).EQ.2) GO TO 2100
      GO TO 4000
C
C     TC 04,06 - DOUBLE THROUGH CRACK AT HOLE
C
 3080 S=C/(RAD+C)
      FB=EXP(1.2133-2.086*S+.8727*S*S)
      FC=COS(PI*(C+RAD)/W)
      FC=SQRT(1./FC)*FB*SQRT(PI*C)
      FA=0.
      IF (KTYPE(1).EQ.2) GO TO 2100
      GO TO 4000
C
C     TC 07 - INTERPOLATION MODEL - THROUGH CRACK
C
 3140 FC=SQRT(PI*C)
      CALL INTP(1,C,A,1,FCC)
      FC=FC*FCC
      FA=0
      IF (KTYPE(1).EQ.2) GO TO 2100
      GO TO 4000
C
C     TC 08,10 - PIN LOADED LUG, SINGLE THROUGH CRACK
C
 3160 Z=(C+2.*RAD)/2.
      E=C/2.
      B=W/2.
      BP=B-E
      FS1=2.*Z/B
      FS2=Z/BP
      PHCP=FUNT1(FS2)
      PHCP=PHCP/SQRT(1.-FS2)
      PHHP=1.-.08*FS1+2.69*FS1**2-.99*FS1**3
      PHWP=1.-.5*FS2+.957*FS2**2-.16*FS2**3
      PHWP=PHWP/SQRT(1.-FS2)
      PHP=(PHCP+PHHP*PHWP)/2.
      PHP=PHP*SQRT(1.+(Z+E)/(Z-E)/9.)
      PHCS=FUNT2(FS2)
      PHCS=PHCS/SQRT(1.-FS2)
      PHSS=FUNT3(FS1)
      PHSS=PHSS*SQRT(1./COS(PI*Z/(2.*BP)))
      S=C/(C+RAD)
      FB=EXP(1.2133-2.205*S+.6451*S*S)
      PHS=(PHCS+PHSS)*FB/2.
```

```
      FCP=PHS*SQRT(PI*C)/(2.*W*TH)
      FC=FCP+PHP*SQRT((Z-E)/(Z+E))/SQRT(PI*Z)/(2.*TH)
      FA=0.
      IF (KTYPE(1).EQ.2) GO TO 2100
      GO TO 4000
C
C     TC 09,11 - PIN LOADED LUG, DOUBLE THROUGH CRACKS
C
 3180 B=W/2.
      Z=RAD+C
      PHCP=FUNT1(Z/B)
      FS1=2.*Z/W
      FS2=2.*Z/H
      PHCP=PHCP/SQRT(1.-FS1)
      PHWP=1.-.5*FS1+.957*FS1**2-.16*FS1**3
      PHWP=PHWP/SQRT(1.-FS1)
      PHHP=1.-.08*FS2+2.69*FS2**2-.91*FS2**3
      PHP=(PHCP+PHWP*PHHP)/2.
      PHCS=FUNT2(Z/B)
      PHCS=PHCS/SQRT(1.-FS1)
      PHSS=FUNT3(FS2)
      PHSS=PHSS*SQRT(1./COS(PI*Z/W))
      S=C/(RAD+C)
      FB=EXP(1.2133-2.086*S+.8727*S*S)
      PHS=(PHCS+PHSS)*FB/2.
      FC=1.05*PHP/(2.*TH*SQRT(PI*Z))
      FC=FC+PHS*SQRT(PI*C)/(2.*W*TH)
      FA=0.
      IF (KTYPE(1).EQ.2) GO TO 2100
      GO TO 4000
C
C     TC 12,14 - SINGLE CRACK AT SINGLE NOTCH
C
 3240 B=H
      FS2=.752+2.02*((B+C)/W)+.37*(1.-SIN(PI*(B+C)/W/2.))**3
      FW=FS2/COS(PI*(B+C)/W/2.)/1.122
      FW=FW*SQRT(W*2./PI/(B+C)*TAN(PI*(B+C)/W/2.))
      FS1=RAD/B
      IF (FS1.LT. .01) GO TO 3242
      S=C/(B+C)
      FC =FUNT4(S,FS1)
      FC=FC*FW*SQRT(PI*C)
      GO TO 3244
 3242 FC=1.122*SQRT(B+C)*FW
 3244 FA=0.
      IF (KTYPE(1).EQ.2) GO TO 2100
      GO TO 4000
C
C     TC 13,15 - DOUBLE CRACK AT DOUBLE NOTCH
C
 3260 B=H
      FS2=.752+2.02*((B+C)/(W/2.))+.37*(1.-SIN(PI*(B+C)/W))**3
      FW=FS2/COS(PI*(B+C)/W)/1.122
      FW=FW*SQRT(W/PI/(B+C)*TAN(PI*(B+C)/W))
      FS1=RAD/B
      IF (FS1.LT. .01) GO TO 3262
      S=C/(B+C)
      FC =FUNT4(S,FS1)
      FC=FC*FW*SQRT(PI*C)
      GO TO 3264
```

```
 3262 FC=1.122*SQRT(B+C)*FW
 3264 FA=0.
      FW=(1.+.122*(COS(PI*(B+C)/W))**4)*COS(PI*(B+C)/W)
      FC=FC*FW/FS2
      IF (KTYPE(1).EQ.2) GO TO 2100
      GO TO 4000
C
C     TC 16,17 - CRACK OUT OF SHOULDER
C
 3320 B1=(W-H)/2.
      S1=C/(C+B1)
      FC=W/PI/(C+B1)*TAN(PI*(C+B1)/W)
      FC=SQRT(FC)
      FC=FC*(1.+.122*(COS(PI*(C+B1)/W))**4)/1.122
      FC=FC*SQRT(PI*C)*FUNT4(S1,C1B1)
      FA=0.
      IF (KTYPE(1).EQ.2) GO TO 2100
      GO TO 4000
C
 4000 RETURN
 6002 FORMAT(1HC,'NO COMPACT CRACK FOR PART-THROUGH')
      END
```

```
      FUNCTION FUNP1(X,IX)
      DIMENSION AOVC(25),FUNS(25,2)
C
      DATA AOVC /0.,.04,.07,.12,.15,.21,.34,.58,.72,.775,.86,1.,1.25,
     1 1.49,1.785,2.325,3.45,5.,6.66,10.,25.,50.,100.,10000.,10000./
      DATA FUNS /1.122,1.11,1.1,1.08,1.07,1.04,.97,.84,.77,.75,.71,
     1 .655,.65,.63,.61,.57,.5,.43,.35,.31,.17,.1,.05,0.,0.,
     2 0.,.17,.27,.37,.42,.5,.6,.71,.74,.75,.76,.775,.82,.86,
     3 .9,.96,.975,.99,.998,1.,1.,1.,1.,1.,1./
C
      IF (AOVC(1).GT.X) GO TO 5
      IF (AOVC(25).GE.X) GO TO 10
    5 WRITE (6,6000) X
      STOP
   10 DO 20 I=2,24
      IF (X.LT.AOVC(I)) GO TO 30
   20 CONTINUE
      I=24
   30 J=I-1
      T=AOVC(I)-AOVC(J)
      T=(X-AOVC(J))/T
      FUNP1=FUNS(J,IX)+T*(FUNS(I,IX)-FUNS(J,IX))
      RETURN
C
 6000 FORMAT(1H0,'FUNP1:  X= ',1PE12.3,'  IS OUT OF RANGE')
      END
```

```
      FUNCTION FUNTI(X)
C
      DIMENSION VALUE(14),FUNS(14)
C
      DATA VALUE /0.,.06,.12,.19,.34,.4,.48,.54,.6,.72,.8,.86,.96,1./
      DATA FUNS /1.,.98,1.,1.06,1.24,1.3,1.36,1.38,1.395,1.395,1.38,
     1          1.36,1.32,1.297/
C
      IF (VALUE(1).GT.X) GO TO 5
      IF (VALUE(14).GE.X) GO TO 10
    5 WRITE(6,6000) X
      STOP
   10 DO 20 I=2,14
      IF (X.LE.VALUE(I)) GO TO 30
   20 CONTINUE
      I=14
   30 J=I-1
      T=VALUE(I)-VALUE(J)
      T=(X-VALUE(J))/T
      FUNTI=FUNS(J)+T*(FUNS(I)-FUNS(J))
      RETURN
C
 6000 FORMAT(1H0,'FUNTI:  X = ',1PE12.3,'  IS OUT OF RANGE')
      END
```

```
      FUNCTION FUNT2(X)
C
      DIMENSION VALUE(16),FUNS(16)
C
      DATA VALUE /0.,.06,.13,.18,.2,.26,.32,.62,.7,.76,.8,.86,.9,.94,
     1            .97,1./
      DATA FUNS /1.,.98,.96,.955,.95,.95,.955,1.,1.01,1.01,1.,.98,
     1           .96,.92,.88,.826/
C
      IF (VALUE(1).GT.X) GO TO 5
      IF (VALUE(16).GE.X) GO TO 10
    5 WRITE(6,6000) X
      STOP
   10 DO 20 I=2,16
      IF (X.LE.VALUE(I)) GO TO 30
   20 CONTINUE
      I=16
   30 J=I-1
      T=VALUE(I)-VALUE(J)
      T=(X-VALUE(J))/T
      FUNT2=FUNS(J)+T*(FUNS(I)-FUNS(J))
      RETURN
C
 6000 FORMAT(1H0,'FUNT2:  X = ',1PE12.3,'  IS OUT OF RANGE')
      END
```

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```
      FUNCTION FUNT3(X)
C
      DIMENSION VALUE(16),FUNS(16)
C
      DATA VALUE /0.,.1666,.2,.25,.3333,.5,.5714,.6315,.8,.8888,
     1            1.0909,1.2632,1.6,2.1819,2.6666,4.8007/
      DATA FUNS /1.,1.0542,1.0666,1.075,1.0916,1.25,1.3333,1.4166,
     1          1.625,1.75,2.,2.24,2.72,3.64,4.416,8./
C
      IF (VALUE(1).GT.X) GO TO 5
      IF (VALUE(16).GE.X) GO TO 10
    5 WRITE(6,6000) X
      STOP
   10 DO 20 I=2,16
      IF (X.LE.VALUE(I)) GO TO 30
   20 CONTINUE
      I=16
   30 J=I-1
      T=VALUE(I)-VALUE(J)
      T=(X-VALUE(J))/T
      FUNT3=FUNS(J)+T*(FUNS(I)-FUNS(J))
      RETURN
C
 6000 FORMAT(1H0,'FUNT3:  X = ',1PE12.3,'  IS OUT OF RANGE')
      END
```

```
      FUNCTION FUNT4(S,R)
C
      DIMENSION SVAL(9),RVAL(8),TABL(8,9)
C
      DATA SVAL /.01,.05,.1,.2,.3,.4,.6,.8,1./
      DATA RVAL /0.,.25,.333,.5,1.,2.,4.,1.E+61/
      DATA TABL /11.22,9.5,8.4,5.8,3.5,2.3,1.5,1.122,
     2           5.02,5.02,5.02,4.1,3.,2.2,1.45,1.122,
     3           3.55,3.55,3.55,3.5,2.8,2.2,1.4,1.122,
     4           2.51,2.51,2.51,2.51,2.4,2.,1.35,1.122,
     5            2.05,2.05,2.05,2.05,2.,1.8,1.3,1.122,
     6           1.77,1.77,1.77,1.77,1.77,1.7,1.25,1.122,
     7           1.45,1.45,1.45,1.45,1.45,1.35,1.2,1.122,
     8           1.25,1.25,1.25,1.25,1.25,1.25,1.18,1.122,
     9           1.122,1.122,1.122,1.122,1.122,1.122,1.122,1.122/
C
      IF (S.LT.SVAL(1)) GO TO 1000
      IF (S.GT.SVAL(9)) GO TO 1000
      IF (R.LT.RVAL(1)) GO TO 2000
      IF (R.GT.RVAL(8)) GO TO 2000
C
      DO 10 IS=2,9
      IF (S.LT.SVAL(IS)) GO TO 20
   10 CONTINUE
      IS=9
   20 DO 30 IR=2,8
      IF (R.LT.RVAL(IR)) GO TO 40
   30 CONTINUE
      IR=8
   40 ISM1=IS-1
      IRM1=IR-1
      PS=SVAL(IS)-SVAL(ISM1)
      PS=(S-SVAL(ISM1))/PS
      PR=RVAL(IR)-RVAL(IRM1)
      PR=(R-RVAL(IRM1))/PR
      FUNT4=(1.-PS)*(1.-PR)*TABL(IRM1,ISM1)+PS*(1.-PR)*TABL(IRM1,IS)
      FUNT4=FUNT4+PR*(1.-PS)*TABL(IR,ISM1)+PS*PR*TABL(IS,IR)
      RETURN
C
 1000 WRITE(6,6000) S
      STOP
 2000 WRITE(6,6005) R
      STOP
C
 6000 FORMAT(1H0,'FUNT4:  S = ',1PE12.3,' IS OUT OF RANGE')
 6005 FORMAT(1H0,'FUNT4:  R/B= ',1PE12.3,' IS OUT OF RANGE')
      END
```

```
      FUNCTION FUNT5(R,S)
C
      DIMENSION SVAL(11),RVAL(11),TABL(11,11)
C
      DATA SVAL /1.01,1.02,1.05,1.07,1.1,1.15,1.2,1.3,1.5,2.,3./
      DATA RVAL /.02,.04,.06,.08,.1,.12,.14,.18,.22,.26,.3/
      DATA TABL /1.75,3.,4.,4.5,5.,6.,7.,8.,8.5,9.,9.,
     1           1.2,1.75,2.8,3.5,4.,4.3,4.7,5.,6.,6.5,7.,
     2           .95,1.38,1.85,2.,3.,3.3,3.6,4.,4.5,4.75,5.,
     3           .87,1.25,1.63,2.,2.7,3.1,3.5,4.,4.4,4.7,5.,
     4           .82,1.12,1.5,1.87,2.3,3.,3.5,4.,4.5,4.75,5.,
     5           .75,1.15,1.5,2.,2.6,4.4,5.,6.5,7.5,8.5,9.5,
     6           .7,1.15,1.45,1.85,2.25,5.,6.3,7.5,8.5,8.5,9.5,
     7           .55,1.1,1.42,1.84,3.3,5.,6.,7.5,8.5,9.5,10.,
     8           .44,1.35,2.,3.5,4.4,5.,6.,8.,9.,10.,11.,
     9           .36,1.7,5.,5.,6.,6.5,7.,9.,10.,11.,12.,
     A           .18,3.,5.,7.,8.,9.,10.,11.,12.,12.,12./
C
      IF (S.GT.SVAL(11)) GO TO 1000
      IF (R.GT.RVAL(11)) GO TO 2000
      IF (S.GE.SVAL(1)) GO TO 5
      S=1.01
    5 IF (R.GE.RVAL(1)) GO TO 6
      R=.02
    6 CONTINUE
C
      DO 10 IS=2,11
      IF (S.LT.SVAL(IS)) GO TO 20
   10 CONTINUE
      IS=11
   20 DO 30 IR=2,11
      IF (R.LT.RVAL(IR)) GO TO 40
   30 CONTINUE
      IR=11
   40 ISM1=IS-1
      IRM1=IR-1
      PS=SVAL(IS)-SVAL(ISM1)
      PS=(S-SVAL(ISM1))/PS
      PR=RVAL(IR)-RVAL(IRM1)
      PR=(R-RVAL(IRM1))/PR
      FUNT5=(1.-PS)*(1.-PR)*TABL(IRM1,ISM1)+PS*(1.-PR)*TABL(IRM1,IS)
      FUNT5=FUNT5+PR*(1.-PS)*TABL(IR,ISM1)+PS*PR*TABL(IS,IR)
      RETURN
C
 1000 WRITE(6,6000) S
      STOP
 2000 WRITE(6,6005) R
      STOP
C
 6000 FORMAT(1H0,'FUNT5:  W/H = ',1PE12.3,' IS OUT OF RANGE')
 6005 FORMAT(1H0,'FUNT5:  RAD/H= ',1PE12.3,' IS OUT OF RANGE')
      END
```

```
      PROGRAM SCPLCT(INPUT,OUTPUT,TAPE8=INPUT,TAPE5=INPUT,
     *               TAPE6=OUTPUT,PLOT)
C     THIS ROUTINE GENERATE PLOTS ON AN SC4020 FROM A PREVIOUSL
C     GENERATED DATA FILE
C
C
C     CONSTANTS AND DATA DECLARATIONS
C
      INTEGER CDTITL,CDDATA,CDDEND,CDHDR1,CDHDR2,CDHDR3,CDHDR4
      INTEGER CDHDR5,CDHDR6,Y1SYMB,Y2SYMB
      INTEGER TITLE(6),FHDRS(8,6)
C     INTEGER TITLE(9),FHDRS(13,6)
      INTEGER CDTYPE,NDPTS,NPLOTS,NLABLS,MXDPTS,CAMRAS,ADARY(4)
      INTEGER NPLOTS,ERRFLG,RX1,RX2,RX3,RX4,RY1,RY2,RY3,RY4
      INTEGER B1,B2,RB1
C
C     MAX OF 200 DATA POINTS
C
      REAL XVAL(201),Y1VAL(201),Y2VAL(201)
      REAL XMAX,YMAX,XMIN,YMIN
      REAL XMAXIN,YMAXIN,XMININ,YMININ
      REAL XINCIN,YINCIN,XINC,YINC
      REAL CYPBLK,X1,X2,Y1,Y2
      REAL XB1,XB2
      REAL YMXTST(4)
      DATA CDTITL/4HTITL/
      DATA CDDATA/4HDATA/
      DATA CDDEND/4HHDRS/
      DATA CDHDR1/4HHDR1/
      DATA CDHDR2/4HHDR2/
      DATA CDHDR3/4HHDR3/
      DATA CDHDR4/4HHDR4/
      DATA CDHDR5/4HHDR5/
      DATA CDHDR6/4HHDR6/
      DATA Y1SYMB/1HX/
      DATA Y2SYMB/1HO/
      DATA MXDPTS/200/
      DATA YMXTST/.1,.5,1.,5./
C
C     INITIALIZE
C
      XMIN = 0.
      YMIN = 0.
      NPLOTS = 1
C
C     READ PARAMETER CARD
C
      READ (5,1000) XMAXIN,YMAXIN,XINCIN,YINCIN,CAMRAS,
     *              ADARY
 1000 FORMAT (4F10.4,I4,4A6)
C
C     PRINT INPUT SPECIFICATIONS
C
      WRITE (6,2000)
```

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```
 2000 FORMAT (/≠ INPUT SPECIFICATIONS≠//)
      WRITE (6,2010) XMAXIN,YMAXIN,XINCIN,YINCIN,CAMRAS,
     *              ADARY
 2010 FORMAT (≠ MAXIMUM X                = ≠, 1PE10.3/
     *        ≠ MAXIMUM Y                = ≠, 1PE10.3/
     *        ≠ INCREMENT X              = ≠, 1PE10.3/
     *        ≠ INCREMENT Y              = ≠, 1PE10.3/
     *        ≠ CAMARAS                  = ≠, I3/
     *        ≠ SPECIAL INSTRUCTIONS = ≠, 4A6////)
C
C     DEFAULT SETTINGS IF NOT INPUT
C
      IF (CAMRAS .LE. 0) CAMRAS = 35
C
C     START PLOT
C
C     CALL IDENT (CAMRAS,ADARY)
C
C     INITIAL READ
C
C     READ (8,1010,END=999) CDTYPE,TITLE,CYPBLK
      READ (8,1010) CDTYPE,TITLE,CYPBLK
      IF (EOF(8)) 999,35
C
C     MAIN PGM LOGIC
C
      CALL PRINTV (-20,20HAAAAAAAAAAAAAAAAAAAA,300,100)
      CALL PRINTV (-20,20HBBBBBBBBBBBBBBBBBBBB,280,100)
      CALL PRINTV (-20,20HCCCCCCCCCCCCCCCCCCCC,260,100)
      CALL PRINTV (-20,20HDDDDDDDDDDDDDDDDDDDD,240,100)
      CALL PRINTV (-20,20HEEEEEEEEEEEEEEEEEEEE,220,100)
      CALL PRINTV (-20,20HFFFFFFFFFFFFFFFFFFFF,200,100)
      CALL FRAMEV(3)
   30 CONTINUE
      NPLOTS = NPLOTS + 1
C
C     INPUT DATA FOR A PLOT
C
C     READ (8,1010,END=999) CDTYPE,TITLE,CYPBLK
      READ (8,1010) CDTYPE,TITLE,CYPBLK
      IF (EOF(8)) 999,32
 1010 FORMAT (A4,4X,5A10,A4,9X,E9.0)
C1010 FORMAT (A4,4X,9A6,9X,E9.0)
   32 CONTINUE
C
C     ADVANCE FRAME FOR NEXT PLOT
C
      CALL FRAMEV(3)
   35 CONTINUE
C
C     IF NOT TITLE CARD - SEQ ERROR
C
      IF (CDTYPE .NE. CDTITL) GO TO 970
      NOPTS = 0
      XMAX = 0.
```

```
      YMAX = 0.
C
C     MAIN DATA READ LOOP
C
   50 CONTINUE
      NDPTS = NDPTS + 1
      READ (8,1020) CDTYPE,Y1VAL(NDPTS),Y2VAL(NDPTS),XVAL(NDPTS)
 1020 FORMAT (A4,3E12.3)
C
C     CHECK FOR END OF DATA VALUES
C
      IF (CDTYPE .EQ. CDDEND) GO TO 100
C
C     ERROR IF NOT DATA CARD
C
      IF (CDTYPE .NE. CDDATA) GO TO 980
C
C     ERROR IF MAX DATA POINTS EXCEEDED
C
      IF (NDPTS .GT. MXDPTS) GO TO 975
C
C     ACCUMULATE MAX DATA VALUES
C
      XMAX = AMAX1(XMAX,XVAL(NDPTS))
      YMAX = AMAX1(YMAX,Y1VAL(NDPTS),Y2VAL(NDPTS))
      GO TO 50
  100 CONTINUE
C
C     ADJUST NUMBER OF DATA POINTS COUNTER
C
      NDPTS = NDPTS - 1
C
C     READ HEADER CARDS
C
      READ (8,1030) CDTYPE,(FHDRS(I,1),I = 1,8)
 1030 FORMAT (A4,7A10,A6)
C1030 FORMAT (A4,12A6,A2)
      IF (CDTYPE .NE. CDHDR1) GO TO 985
      READ (8,1030) CDTYPE,(FHDRS(I,2),I = 1,8)
      IF (CDTYPE .NE. CDHDR2) GO TO 985
      READ (8,1030) CDTYPE,(FHDRS(I,3),I = 1,8)
      IF (CDTYPE .NE. CDHDR3) GO TO 985
      READ (8,1030) CDTYPE,(FHDRS(I,4),I = 1,8)
      IF (CDTYPE .NE. CDHDR4) GO TO 985
      READ (8,1030) CDTYPE,(FHDRS(I,5),I = 1,8)
      IF (CDTYPE .NE. CDHDR5) GO TO 985
      READ (8,1030) CDTYPE,(FHDRS(I,6),I = 1,8)
      IF (CDTYPE .NE. CDHDR6) GO TO 985
C
C     SET UP PARMS FOR THIS GRAPH
C
C     IF INPUT MAXS LT CALCULATED MAXS - INPUTS ARE OVERRIDDEN
C
  150 CONTINUE
      IF (XMAXIN .GE. XMAX) GO TO 158
```

```
      I = 0
C
C     ADJUST XMAX
C
  152 CONTINUE
      I = I + 1
      IF (I .GT. 100) GO TO 965
      IF (10**I .LT. XMAX) GO TO 152
      XMAX = 10**I
      GO TO 160
  158 CONTINUE
      XMAX = XMAXIN
  160 CONTINUE
      IF (YMAXIN .GE. YMAX) GO TO 168
C
C     ADJUST YMAX
C
      DO 162 I = 1,4
      IF (YMXTST(I) .LT. YMAX) GO TO 162
      YMAX = YMXTST(I)
      GO TO 170
  162 CONTINUE
      I = 0
  164 CONTINUE
      I = I + 1
      IF (I .GT. 100) GO TO 965
      IF (10**I .LT. YMAX) GO TO 164
      YMAX = 10**I
      GO TO 170
  168 CONTINUE
      YMAX = YMAXIN
C
C     COMPUTE INCREMENTS
C
  170 CONTINUE
C
C     CALCULATE X INCREMENT IF NOT SPECIFIED
C
      IF (XINCIN .GT. 0.) GO TO 175
  172 CONTINUE
      XINC = XMAX / 10.
      GO TO 180
C
C     IF SPECIFIED INCREMENT WOULD ALLOW MORE THAN 10 TIC MARKS
C     OVERRIDE
C
  175 CONTINUE
      IF (XMAX/XINCIN .GT. 10.) GO TO 172
      XINC = XINCIN
C
C     CALCULATE Y INCREMENT IF NOT SPECIFIED
C
  180 CONTINUE
      IF (YINCIN .GT. 0.) GO TO 185
  182 CONTINUE
```

```
      YINC = YMAX / 10.
      GO TO 190
C
C     IF SPECIFIED INCREMENT WOULD ALLOW MORE THAN 10 TIC MARKS
C     OVERRIDE
C
  185 CONTINUE
      IF (YMAX/YINCIN .GT. 10.) GO TO 182
C
C     OUTPUT CALCULATED SPECIFICATIONS
C
  190 CONTINUE
      WRITE (6,2020) NPLOTS,NDPTS,XMAX,YMAX,XINC,YINC,CYPBLK
 2020 FORMAT (//≠ SPECIFICATIONS FOR PLOT ≠,I3//
     *             ≠ NUMBER OF DATA PTS  = ≠, I3/
     *             ≠ MAXIMUM X                 = ≠, 1PE10.3/
     *             ≠ MAXIMUM Y                 = ≠, 1PE10.3/
     *             ≠ INCREMENT X               = ≠, 1PE10.3/
     *             ≠ INCREMENT Y               = ≠, 1PE10.3/
     *             ≠ CYCLES PER BLOCK          = ≠, 1PE10.3)
C
C     DEFINE AND SET SCALING FACTORS FOR PLOTTING AREA
C
  200 CONTINUE
      CALL XSCALV (XMIN,XMAX,150,50)
      CALL YSCALV (YMIN,YMAX,150,50)
C
C     DRAW SQUARE SURROUNDING PLOT AREA
C
  220 CONTINUE
C
C     GET RASTER COORDS OF ENDPOINTS
C
C     CALL XSCLV1 (XMIN,RX1,ERRFLG)
C     CALL XSCLV1 (XMAX,RX2,ERRFLG)
C     CALL YSCLV1 (YMIN,RY1,ERRFLG)
C     CALL YSCLV1 (YMAX,RY2,ERRFLG)
      RX1 = IXV(XMIN)
      RX2 = IXV(XMAX)
      RY1 = IYV(YMIN)
      RY2 = IYV(YMAX)
C
C     DRAW SQUARE
C
C     CALL XAXSTP (RX1,RY1,RX2)
C     CALL YAXSTP (RX2,RY1,RY2)
C     CALL XAXSTP (RX2,RY2,RX1)
C     CALL YAXSTP (RX1,RY2,RY1)
      CALL XAXISV (RX1,RY1,RX2)
      CALL YAXISV (RX2,RY1,RY2)
      CALL XAXISV (RX2,RY2,RX1)
      CALL YAXISV (RX1,RY2,RY1)
C
C     DRAW TITLE (ASSUME CENTERED ON INPUT)
C
```

```
      CALL RITE2V (56,13,1023,90,1,54,1,TITLE,ERRFLG)
C
C     DRAW AXIS TITLES
C
      CALL PRINTV (-6,6HCYCLES,RX1+390,RY1-40)
      CALL PRINTV (-6,6HBLOCKS,RX1+390,RY2+43)
      CALL APRNTV (0,-14,-6,6HINCHES,RX1-125,RY1+454)
C
C     DRAW INFO LINES
C
C
C     SET UP TO DRAW INFO LINES ABOVE OR BELOW CENTER
C     DEPENDING ON INITIAL VALUES OF DATA
C
      RY3 = 950
      IF ( (Y2VAL(1) + Y1VAL(1)) / 2. .GT. YMAX / 2. ) RY3 = 29
      DO 260 I = 1,6
      CALL PRINTV (76,FHDRS(1,I),RX1+16,RY3)
      RY3 = RY3 - 15
  260 CONTINUE
C
C     DRAW SYMBOL LEGEND
C
      RY3 = RY3 - 10
      CALL PRINTV (-13,13HSYMBOLS: A = ,RX1+16,RY3)
      CALL PRINTV (1,Y1SYMB,RX1+124,RY3)
      RY3 = RY3 - 15
      CALL PRINTV (-13,13H         C = ,RX1+16,RY3)
      CALL PRINTV (1,Y2SYMB,RX1+124,RY3)
C
C     GENERATE TIC MARKS AND LABELS
C
C
C     LABEL AND TIC MARK ORIGIN (0,0)
C
      CALL LINE2V (RX1-4,RY1,8,0)
      CALL LINE2V (RX1,RY1-4,0,8)
      CALL PRINTV (-1,1H0,RX1,RY1-16)
      CALL PRINTV (-1,1H0,RX1-16,RY1)
C
C     DRAW X AXIS LABELS
C
      X1 = XMIN
      NLABLS = XMAX / XINC - .99
      DO 340 I = 1,NLABLS
C
C     GET NEXT TIC MARK VALUE
C
      X1 = X1 + XINC
C     CALL XSCLV1 (X1,RX3,ERRFLG)
      RX3 = IXV(X1)
C
C     DRAW TIC MARK
C
      CALL LINE2V (RX3,RY1-4,0,8)
```

```
C
C     LABEL TIC MARK
C
      CALL LABLV (X1,RX3-35,RY1-18,-2,1,1)
C
C     COMPUTE BLOCK LABEL VALUE
C
      B1 = X1 / CYPBLK
      B2 = B1 + 1
      XB1 = B1 * CYPBLK
      XB2 = B2 * CYPBLK
C
C     GET VALUE CLOSEST TO CYCLE TIC MARK
C
      IF ( ABS(XB2-X1) .GT. ABS(X1-XB1) ) GO TO 320
      XB1 = XB2
      B1 = B2
  320 CONTINUE
C
C     IF MORE THAN ONE HALF A CYCLE TIC MARK AWAY DON≠T DRAW
C
      IF (XB1 .GT. X1 + XINC/2. .OR. XB1 .LT. X1 - XINC/2.) GO
C
C     GET RASTER COORDS
C
C     CALL XSCLV1 (XB1,RB1,ERRFLG)
      RB1 = IXV(XB1)
C
C     DRAW TIC MARK
C
      CALL LINE2V (RB1,RY2-4,0,8)
C
C     LABEL TIC MARK
C
      XB1 = B1
      CALL LABLV (XB1,RB1-35,RY2+12,-2,1,1)
  340 CONTINUE
C
C     LAST TIC MARK AT XMAX (UNLESS UNUSUAL USER INCREMENT
C     SPECIFIED)
C
C     CALL XSCLV1 (X1+XINC,RX3,ERRFLG)
      RX3 = IXV(X1+XINC)
      IF (IABS(RX3-RX2) .GE. 5) GO TO 360
      CALL LINE2V (RX2,RY1-4,0,8)
      CALL LABLV(XMAX,RX2-35,RY1-18,-2,1,1)
C
C     DRAW LAST BLOCK LABEL IF IN PLOT AREA
C
C
C     COMPUTE BLOCK LABEL VALUE
C
      B1 = XMAX / CYPBLK
      XB1 = B1 * CYPBLK
C
```

```
      C     IF MORE THAN ONE HALF A CYCLE TIC MARK AWAY DON*T DRAW
      C
            IF (XB1 .LT. XMAX - XINC/2.) GO TO 360
      C
      C     GET RASTER COORDS
      C
      C     CALL XSCLV1 (XB1,RB1,ERRFLG)
            RB1 = IXV(XB1)
            CALL LINE2V (RB1,RY2-4,0,8)
            XB1 = B1
            CALL LABLV (XB1,RB1-35,RY2+12,-2,1,1)
      C
      C     DRAW Y AXIS LABELS
      C
        360 CONTINUE
            Y1 = YMIN
            NLABLS = YMAX / YINC - .99
            DO 380 I = 1,NLABLS
            Y1 = Y1 + YINC
      C     CALL YSCLV1 (Y1,RY3,ERRFLG)
            RY3 = IYV(Y1)
      C
      C     DRAW TIC MARK
      C
            CALL LINE2V (RX1-4,RY3,8,0)
      C
      C     LABEL TIC MARK
      C
            CALL LABLV (Y1,RX1-92,RY3,-3,1,1)
        380 CONTINUE
      C
      C     LAST TIC MARK AT YMAX (UNLESS UNUSUAL USER INCREMENT
      C     SPECIFIED
      C
      C     CALL YSCLV1 (Y1+YINC,RY3,ERRFLG)
            RY3 = IYV(Y1+YINC)
            IF (IABS(RY3-RY2) .GE. 5) GO TO 400
            CALL LINE2V(RX1-4,RY2,8,0)
            CALL LABLV (YMAX,RX1-92,RY2,-3,1,1)
      C
      C     PLOT DATA
      C
        400 CONTINUE
      C     CALL XSCLV1 (XVAL(1),RX3,ERRFLG)
      C     CALL YSCLV1 (Y1VAL(1),RY3,ERRFLG)
      C     CALL YSCLV1 (Y2VAL(1),RY4,ERRFLG)
            RX3 = IXV(XVAL(1))
            RY3 = IYV(Y1VAL(1))
            RY4 = IYV(Y2VAL(1))
      C
      C     PLOT SYMBOL AT FIRST DATA POINT (BOTH Y VALUES)
      C
            CALL PLOTV (RX3,RY3,Y1SYMB)
            CALL PLOTV (RX3,RY4,Y2SYMB)
      C     CALL PLOTV (RX3,RY3,20)
```

```
      C      CALL PLOTV (RX3,RY4,29)
             IF (NDPTS .LE. 1) GO TO 431
      C
      C      LOOP FOR REST OF DATA POINTS
      C
             DO 430 I = 2,NDPTS
      C
      C      GET COORDS OF NEXT POINT
      C
      C      CALL XSCLV1 (XVAL(I),RX1,ERRFLG)
      C      CALL YSCLV1 (Y1VAL(I),RY1,ERRFLG)
      C      CALL YSCLV1 (Y2VAL(I),RY2,ERRFLG)
             RX1 = IXV(XVAL(I))
             RY1 = IYV(Y1VAL(I))
             RY2 = IYV(Y2VAL(I))
      C
      C      PLOT SYMBOL AT DATA POINT (FOR BOTH Y VALUES)
      C
             CALL PLOTV (RX1,RY1,Y1SYMB)
             CALL PLOTV (RX1,RY2,Y2SYMB)
      C      CALL PLOTV (RX1,RY1,20)
      C      CALL PLOTV (RX1,RY2,29)
      C
      C      DRAW LINE FROM PREVIOUS POINT TO THIS POINT
      C
             CALL LINEV(RX3,RY3,RX1,RY1)
             CALL LINEV (RX3,RY4,RX1,RY2)
      C
      C      SET UP FOR NEXT POINT
      C
             RX3 = RX1
             RY3 = RY1
             RY4 = RY2
         430 CONTINUE
         431 CONTINUE
      C
      C      GO TO NEXT PLOT
      C
             GO TO 30
      C
      C      MAX OF 10**100 EXCEEDED
      C
         965 CONTINUE
             WRITE (6,2990)
        2990 FORMAT (/≠ MAX VALUE OF 10**100 EXCEEDED≠)
             GO TO 995
      C
      C      FIRST CARD IN DATA GROUP NOT A TITLE CARD
      C
         970 CONTINUE
             WRITE (6,3000)
        3000 FORMAT (/≠ MISSING TITLE CARD - DATA SEQUENCE ERROR≠)
             GO TO 995
      C
      C      MAX DATA POINTS EXCEEDED
```

```
C
  975 CONTINUE
      WRITE (6,3010) MXDPTS
 3010 FORMAT (/1X,I4,≠ DATA POINT MAXIMUM EXCEEDED≠)
      GO TO 995
C
C     DATA CARD EXPECTED BUT NOT READ
C
  980 CONTINUE
      WRITE (6,3020)
 3020 FORMAT (/≠ MISSING EXPECTED DATA CARD - DATA SEQUENCE ERR
      GO TO 995
C
C     HDR CARD MISSING
C
  985 CONTINUE
      WRITE (6,3030)
 3030 FORMAT (/≠ MISSING HDR CARD - DATA SEQUENCE ERROR≠)
      GO TO 995
C
C     GENERAL ERROR TERMINATION
C
  995 CONTINUE
      WRITE (6,3090)
 3090 FORMAT (//≠ ***  RUN TERMINATED ****≠)
C     CALL ENDJOB
      STOP 777
  999 CONTINUE
C     CALL ENDJOB
      STOP
      END
```


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